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U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE.
HENRY S. GRAVES, Forester.

SYSTEMATIC FIRE PROTECTION IN THE CALIFORNIA FORESTS.

BY

COERT DUBOIS,
DISTRICT FORESTER, DISTRICT 5.

FOR FOREST OFFICERS IN DISTRICT 5.
(Not for public distribution.)

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SYSTEMATIC FIRE PROTECTION IN THE CALIFORNIA FORESTS.

PART I.—FINANCE AND INDIRECT CONTROL.

CHAPTER I.

THE NEED OF FIRE PROTECTION.

Why Protect the Forests?

Before we can enter into a study of methods and appliances, an attempt must be made to gain as concrete an idea as possible of the value to the public of protecting their forests from fire.

To be most useful and generally understandable the value of forest protection must be measured in dollars and cents whenever that is possible. Then the excess in money value of the products of a protected forest over the money value of the products of an unprotected forest is the worth of protection to the public.

The capital value of a municipal bond lies not in the amount of luxuries that could be purchased by the $1,000 invested in it, but in its power to produce an income of $60 each year. If the coupons are not cut off and collected annually, a larger sum accumulates which can be collected at some future time without lessening the original $1,000. With the forest, the capital value is the soil, which, in combination with moisture and sunlight, has the power to produce an income in the shape of wood and is expressible in terms of dollars. The big clean sugar pines standing in the forest are not, from the point of view of the United States public, the capital value of that forest; they are accumulated income, due and collectible. When they are cut, the producing power of the soil capital remains as great as before.

Protection Increases Production.

Now, a mixed conifer forest, in which all age classes are represented and which is run over periodically by ground fires, will have produced at the end of a rotation of 150 years something less than it would have produced if no fire had touched it. How much less? We know exactly what that forest looks like. Assume a square acre in the typical timber of the west slope of the Sierras. Near the crest of the slope is a grove of a few big sugar and yellow pines, their crowns touching, and a carpet of needles underneath. Along the bottom of the square is a strip of thick young growth of fir varying from 6-inch seedlings to 20-foot saplings. A group of 12-inch yellow-pine poles stands at one side, but the center of the square and the other side is occupied by scattering clumps of manzanita. A few twisted dry whips show that young yellow pine trees once occupied that ground, but following a ground fire manzanita seized it and now uses all the light. One-third of our square acre is fully stocked but not producing to capacity because the overdue income has not been collected—a lack of production not chargeable to fire. Another third is fully stocked with saplings and poles and is producing to capacity, which, if rated at 500 board feet per acre per year, is 166 board feet a year. The remaining third is producing nothing, and its lack of production is chargeable to fire. Had that fire been kept out the area would have been producing yellow pine at the rate of 166 board feet a year. The public is losing 31½ cents a year by reason of this fire and will continue to lose it until this third of the acre is producing to capacity again.

Financial Loss Through Fires.

Except in the high mountains one can go nowhere in the forests of California without seeing traces of old fires. The acre just described is typical of many millions of acres. The loss of production is evidenced not only by acres seized and held by worthless species as a result of fires but by white fir rendered worthless by Indian Paint fungus, and cedar by dry rot, which entered through fire wounds. It is reasonably safe to say that throughout the whole area of public-owned forest in California, fires have reduced the present annual production one-third below normal, and that wherever a remnant of the old forest is left this can again be brought up to normal by reasonable immunity from fire. Assuming a conservative 300 board feet per acre per annum as the average normal production over the aggregate forest area of 10,000,000 acres in public ownership, this loss reaches the figure of 1,000,000,000 board feet per year, worth at present rates $2,500,000.

As a matter of fact, the people of the United States can expend annually $250,000 on protecting their forest properties in California from fire, and cease to lose (or they gain) $2,500,000 worth of wood a year; and this on the basis of appraisable benefits only, disregarding the unappraisable benefits of maintenance of cover on the watersheds and keeping usable the health and recreation grounds of the people.

While this justifies the protection of our Forest area as a whole, it does not relieve us of the responsibility of economic justification of the protection of each portion of it viewed independently and judged according to the same principle. The product of each area must be studied—whether it is wood or a more stable flow of streams needed to secure agricultural crops in the valleys below, or its use as a health and pleasure ground for the people. Against the value of these products must be measured the extent to which fire protection secures them and the cost to attain it. Such studies have resulted, and will result, in the elimination from the Forest area (and the cessation of protection expenditures upon them) of certain isolated blocks of poor quality timber, of brush watersheds draining into uncultivable deserts, and of brush areas from which no living streams come and where, even without the forest cover, erosion does only slight local damage.

Object of Fire Protection.

In any line of endeavor consistent progress can be made only when the end to be attained is clearly defined. It may be stated as a general principle that the object of forest fire protection is to secure from each acre in the forest the maximum of all forest products which its soil is capable of producing. It is self-evident that complete immunity from fire is the ideal in accomplishing this object, but complete immunity is not possible. A vast area of inflammable forest, a regularly recurring dry season, a large number of unpreventable lightning fires starting each year, and a limit to the money for prevention—all combine to put this ideal outside the realm of possibility. If anything short of complete immunity is to serve, we must state how far short of it will be considered a practical accomplishment of the end desired. Here again the forester must combine the functions of economist and engineer. He must state the problem and then solve it.

Protection Standards.

At present the total money resources that can be applied to protection are more or less fixed by the practical limitations of congressional appropriations. From past performances with the use of these funds under fire conditions that we are now able to state, we are in position to set a degree of immunity from fire which we can reasonably hope to attain. Instead of taking a fixed sum of money and getting for it all the protection a Forest organization thinks it can, the administrative officers should be in position to say "Here is a sum of money for which you should deliver so much fire protection. If you do not, I shall ask why. If you deliver more, I shall find out how you did it and see that the other organizations do it the same way." Furthermore, suppose it is found that a reasonable degree of protection can not be bought for the money available, and suppose it can be shown concretely why not. Congress, if it

accepts that degree of protection as desirable at the price, will furnish the money. The public, too, have the right to know in something other than vague terms how much protection the Forest Service is giving them for their money.

Protection standards are necessary, then, as one of the fixed factors in the problem of protection finances, for measuring the absolute and comparative efficiency of the units of organization and methods used in order to increase efficiency all along the line, and for reporting results accomplished both to Congress and to the public. They could be stated either in terms of average acreage per fire, or in average time from start to control, but as the District has been thinking in terms of the former, and as figures on the latter have not been secured, average acreage will be used.

The results of the season of 1913 are representative of what the organization can do in a bad year after three years of study on the subject, and may well be used as a basis in establishing protection standards. The following will hold for District 5 until further notice:

For timber, all types.................................. 10 acres per fire.
For open, including brush and grass................ 100 acres per fire.

These standards are arbitrary, it is recognized. They are established arbitrarily and will hold until, by study and test, it can be determined (1) what degree of protection can be delivered for a given sum under known conditions; (2) just the amount that, expended under known conditions, will be most to the public interest; and (3) a scientifically correct expression of the standards of protection that that amount of money should buy.

CHAPTER II.

ELEMENTS OF FIRE DANGER.

Six Factors.

When a layman riding through the mountains with a Forest officer asks, "What is the fire danger here?" he is generally answered in vague terms, such as, "Very high," "Practically none," or "About average." In reaching even this indefinite conclusion, what mental processes does the Forest officer go through? What factors added together make that total called "fire danger"? Incisive definitions of terms and analyses of factors are very necessary in order to state the answer to that question concretely. We must have concrete answers in order to insure the right distribution of protection resources. Six factors go to make up fire danger in any given area: Inflammability, season, risk, controllability, liability, and safety.

Inflammability.

Inflammability, the factor of first importance, is composed of four elements: The amount of fuel on the ground, ease of ignition, dryness or lack of moisture in the cover, and slope. It is expressed in (and may be defined as) the normal rate at which a fire increases in area. A lighted cigarette dropped in thick bear clover in which no needles are hanging will not often set it afire, while with the same wind a cigarette dropped into dry foxtail grass is almost sure to do so. The ignition factor of the foxtail is higher than that of bear clover, or, in other words, it takes less heat units to cause it to flame. So, if with the same wind 10 acres of foxtail will burn over in the time that it takes a fire in bear clover to cover 1 acre, we may say that the comparative inflammability of foxtail to bear clover is as 10 to 1.

Supervisor Wynne has worked out, from a large number of fire figures, the following rates of spread on slopes up to 40 per cent and wind up to 8 miles per hour:

Type.	Acres per hour.	Comparative rating.
Grass	223	100
Brush	51	23
Timber	24	11

Dryness affects rate of spread of fires in direct ratio to the lack of moisture in the material subjected to heat. Thus, with the same wind and the same degree of slope, pine needles on a south slope—because they contain less moisture to be evaporated—require less heat to ignite them and keep them burning than on a north slope. The gradient of the slope on an uphill fire effects inflammability in offering a larger fuel surface to the flames, more fuel being subjected to the same heat. On a downhill fire the rate of spread is hastened by rolling brands set free by the gradually disappearing ground mat.

Season.

Each area has its normal fire season. Indian Creek, on the Klamath Forest, and Arroyo Seco, on the Angeles Forest, each has its average number of dry days a year, each its average summer temperature, and each its summer wind velocity. The combination of these averages makes for each locality its individual seasonal factor in its fire danger.

Risk.

The third factor is risk, which will be defined as the likelihood of fires starting. Nine out of ten fires start accidentally, and it may be argued that a factor which will vary so from year to year can not be taken into consideration with any degree of precision. Yet we are in no worse case than insurance companies, which base large financial transactions on the likelihood of fires starting, proceeding on the law of averages. By a study of the causes of past fires and determining what cause-factors are still present, the factor of risk may be stated accurately, though it may shift from time to time, and further study may be necessary to rerate it. The actual number of fires in an area may decrease, but by the construction of a road offering a new route of travel the risk factor may be raised.

Controllability.

When a ranger says, "This is a bad country to fight fire in," he means that there are great natural difficulties in the way of removing sufficient inflammable material from in front of a fire to make it go out for lack of fuel. These difficulties may be in the shape of obstructions which render the ground surface difficult to reach and work upon, such as heavy brush, or they may be obstacles such as very steep slopes or thick sapling stands, which impede the quick movement of men. For lack of a better term this factor may be called "controllability," and is defined as the degree of difficulty, by reason of natural conditions, that will be met with in controlling a fire.

Liability.

The factor of liability, as defined by the Protection Manual, is the value of the property subjected to fire hazard. It may be a high direct value, such as mature sugar pine, or a high indirect value, such as chaparral cover on an intensively used stream. Liability may or may not affect protection intensity. In the present stage of forest protection in California, where we are trying first of all to reach one standard of efficiency on every fire that occurs, the value of resources to be protected affects the disposition of protective facilities very little if at all.

Safety.

The safety factor is the degree of ease (or difficulty), by reason of man-made conditions, with which a fire is likely to be controlled. It takes into consideration the human features, which affect the fire danger as controllability does the natural features. But it is the opposite of risk. For example, there is a town of 500 inhabitants adjacent to a forest tract. Land clearing and brush burning on the edge of town, antiprotection sentiment among some of the men, hunters and careless boys going out from the town—all constitute the risk factor of that town. Whereas the 100 available fire fighters, the stores where tools and supplies can be obtained, the communication and transportation routes leading to and from the town, all constitute the safety factor. If both could be expressed mathematically, the risk factor minus the safety factor would equal the *net* risk factor—one of the elements we need in rating fire danger.

A Measure of Fire Danger.

A way must be devised of reducing all of these factors to concrete terms, so that any forest area, after careful study, can be given a rating which will convey to our minds something in the nature of an exact measure of its total fire danger.

Fire insurance companies measure the danger to a given property against an ideal. A house which is as safe as it could possibly be is rated at 100, when every factor which goes to make up its likelihood of burning up is at the minimum. This principle might be applied to forest properties, reversing the rating so that the least possible—or ideal—fire danger is rated at 0 and the highest at 100. When all is said, any such method is simply an application of judgment, but it is better than a lump judgment, because it permits consideration of one element of the fire danger at a time, with certain broad guides or measures which may be kept in mind while the judgment is being exercised.

The factor of inflammability, while very complicated, is summarized in the rate of spread, and an expression of this rate may well be used as a mathematical statement of the factor. Acres per hour are measures which are too large. Square feet are not easy to compute. The rate of advance of a fire is what we are chiefly concerned with, so in expressing rate of spread we will use *lineal feet* of advance with the wind direction per 10-minute interval in an 8-mile wind. The time interval and push of the wind remaining fixed, the rate of speed may be expressed in the number of feet of advance.

Thus dry grass on a slope of over 40 per cent, with an 8-mile wind, may burn 40 feet ahead in 10 minutes; and dry grass on a gentle slope, under the same wind and in the same time, may burn only 20 feet; while heavy brush, on a gentle slope, under the same conditions, might cover 12½ feet in the same length of time.

All these are suppositions, and it will be seen at once that not enough study has been made on rates of spread. Every opportunity to secure such figures should be taken.

Season.

The seasonal factor may be rated by taking the normal number of dry days per year, the average maximum daily temperature for that dry period, and the average daily rate per hour of the wind at 2 p. m. during the same period. These may be compared between areas.

For example, assuming that at Campo Station on the Cleveland Forest the number of dry days is 160, the average maximum temperature is 95°, and the average wind velocity is 10.5 miles per hour, the following (assumed) for Butte Meadows on the Lassen Forest:

Dry days	105
Average maximum temperature	80
Average wind velocity	8

gives a basis for comparing the seasonal factor (factors S 1, S 2, and S 3) of the two localities.

Risk.

Rating the factor of risk can at best be but a matter of judgment, but we can adopt an arbitrary standard for a measure of risk. It may be based upon the number of people a week of average carelessness entering upon or remaining in the tract in question engaged in pursuits which necessarily entail the use of fire in the open (camping, logging, or construction work). The factor may be raised for a group carelessness or antagonism above the average. It may be raised if—though the human risk is low—the lightning risk is high. Thus, on the Big Oak Flat road on the Stanislaus Forest, one of the routes to the Yosemite, possibly 200 people a week travel; but as a group they are rather careful than otherwise with fire.

The factor of safety must be subtracted from the risk factor. It can never, of course, be as high as the risk factor—or there would be no net risk factor at all. It is at its highest where the whole population which constitutes the risk understands thoroughly the fire danger and sympathizes fully with attempts to combat it, and where they are

perfectly organized into auxiliary protection forces and can be placed, properly equipped, on any fire line within minimum time.

The hardest possible place in the district to construct an effective fire barrier would constitute the district's highest controllability factor (factor C). This is probably in the upper reaches of some of the canyons on the Angeles Forest where the slopes lie at an angle of 45°, the chaparral cover is as dense as it can grow, and the region is not reached by trails. Compared with this, the broad levels of mature pine on some of the Sierra forests, under which is a light mat of needles—parts of the Chiquita Basin, for example—would have a decidedly low controllability factor.

To apply any such ratings it will be necessary to work out by intensive field study each factor of the fire danger on a selected unit of area (a typical ranger district) and use the factors found there as arbitrary standards of measure by which to gauge the same factors as they occur on other districts or Forests. Such a study will be undertaken.

Simply for purposes of illustration, suppose that on 20 per cent of this selected ranger district an average rate of spread of a fire in an 8-mile wind of 100 feet per 10 minutes can be expected; on 50 per cent of it, 8 feet; and on the remaining 30 per cent, 15 feet, making the average rate of spread for the district 28.5 feet. Assume that its average summer season consists of 112 days averaging 85° in maximum temperature with an average wind velocity at 2 p. m. of 9 miles an hour. We will say that the district contains a logging operation and is popular with campers. An average of 150 people a week occupy it, but they are of less than average carelessness. It is out of a lightning belt. Further, this risk is discounted by the splendid cooperation given by the loggers, whose mill is on the Service phone line and who will deliver 50 men at any point in the district in 45 minutes.

The district is comparatively level and well supplied with roads. Except for a few steep brush slopes and areas of young growth the forest is open mature pine and fir, and fire is easily controlled anywhere within it.

Suppose we take this imaginary district as a standard by which to rate an actual district—

Then an average rate of spread of 28.5 would equal a factor (I) of 10.
A normal dry period of 112 dry days would equal a factor (S 1) of 10.
An average maximum summer temperature of 85° would equal a factor (S 2) of 10.
A normal summer wind velocity of 9 miles an hour would equal a factor (S 3) of 10.
Where 150 people a week use the area and 50 of them are organized for protection the net risk, or factor R, is 10.
If 80 per cent of the area is open mature forest, comparatively level, the controllability, or factor C, is 10.

If the actual ranger district studied is one where the average rate of spread is 50 feet per 10 minutes, which has normally 120 dry days averaging 90° with a normal wind velocity of 8.5 miles; where 300 people a week travel unorganized and particularly careless with fire, and where the slopes were steep and covered with thick brush, its ratings, compared with the standard district, could be stated somewhat as follows:

Factor I	17.2
S 1	10.7
S 2	10.6
S 3	9.4
R	30.0
C	40.0

This method is entirely theoretical, and has never been worked out in practice. Undoubtedly the factor ratings must be given different weights, and what the weight should be and how they can be mathematically applied are open to discussion.

But criticism of the theory or the difficulties in obtaining data do not do away with the imperative need of a concrete comparison of the sum total of the fire danger between different areas. How else can the district forester know that for a given sum of

money per acre the Trinity Forest should reach the protection standard, while at the same rate the Tahoe Forest can not be expected to? How else can the supervisor make the same comparison between ranger districts? A fire-danger rating is necessary to measure protection efficiency in just the same way a cost-keeping system is necessary to measure manufacturing efficiency.

CHAPTER III.

THE PROTECTION PROBLEM.

Normal Seasons.

While it may be possible to state the fire danger for a given administrative unit within a district in some such terms as were discussed in the foregoing chapter, yet in discussing the fire danger of the district as a whole averages only can be used. It is obviously impossible to compare accurately the inflammability of California forests with those of Florida or Alaska. We can, however, give certain figures and describe concretely certain conditions which will allow us to view our protection problem more closely than we do now. If we can describe the normal season, we will be in position to know when we are entering upon an abnormal one.

We know that the forests of California are inflammable, but we do not know *how* inflammable they are. If the time between start and control on the 1,420 fires in the forests in 1913 averaged 10 hours (a figure which is entirely assumed) and the average acreage per fire is 102.1 acres (a correct figure), then the average rate of spread of all these fires was about 10.2 acres per hour, or 270 feet (square) per 10-minute interval. What is needed is the rate at which *uncontrolled* fires burn. The new fire report is designed to secure figures on this and will give them whenever the time of start is accurately known and the size, time, and wind velocity accurately noted by the first officer arriving.

Mean Annual Precipitation.

The following table shows the mean annual precipitation, by months, at San Francisco over a period of 53 years—from 1849 to 1902. The amounts of precipitation are not applicable to the rest of the State, but its seasonal distribution is applicable; that is, the United States Weather Bureau at San Francisco states that the average dry season all over California is normally composed of as many dry days as the average dry season in San Francisco:

Table I.—*Monthly mean precipitation in California.*

Month.	Dry season.				Rainy season.							
	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
Mean precipitation (in.)	0.14	0.02	0.02	0.23	1.05	2.75	4.80	4.85	3.54	3.14	1.82	0.73
Per cent of total	2				98							

The average California dry season, then, is a period of practically complete drought lasting 122 days from June 1 to September 30. The rains which most affect the fire season are those which fall in May and September.

Normal Temperatures.

Figures on average maximum temperature during this period are one of the gaps in our knowledge which must be supplied. From the meager data available it may be placed at about 85° for that portion of the State within the National Forests. From figures obtained from the United States Weather Bureau at Nevada City, the following may be taken to express normal temperatures for the west slope of the Sierras at an elevation of 2,500 feet:

TABLE II.—*Normal temperatures for west slope of Sierras.*

Month.	Average maximum.	Number of days over 90° F.
	°*F.*	
June	80	6
July	90	19
August	90	12
September	77	2

While July is usually the month of greatest heat, the presence of some green vegetation in the timber belt keeps it from being the month of greatest fire danger. Because of the accumulated drying effects on the ground cover, the warm nights, and the likelihood of winds above normal, the 20-day period from August 5 to 25 may be taken as the "peak" of the normal fire season. After August 25 the nights may be expected to be sufficiently cool to slacken the rate of spread of fires.

Wind Velocity.

The velocity of the normal summer wind on the west slope of the Sierras in the Coast Range and in southern California is about 8 miles per hour. It reaches its daily maximum from 2 p. m. to 4 p. m., and its daily minimum between 4.30 a. m. and 9 a. m. and again between 5.30 p. m. and 8 p. m. On the main ridges throughout the mountains, in large valleys where it gets an unobstructed sweep, and on the east side of the Sierras the normal wind velocity is higher—from 15 to 20 miles an hour.

The following table gives the wind velocities in miles per hour and feet per second:

Miles per hour.	Feet per second.	Remarks.
5	7.33	Gentle.
10	14.67	
12½	18.33	Fresh breeze.
15	22.00	
20	29.33	
25	36.67	Brisk wind.
30	44.00	Strong wind.
40	58.67	High wind.
50	73.33	Storm.

Lightning Fires.

The clearest idea of risk may be obtained from a study of the number of fires over a period of years. Lightning fires are the only strictly unpreventable fires that occur—the only ones not caused by human agency.

Table III shows their proportion to the total number:

TABLE III.—*Fires set by lightning.*

Year.	1908	1909	1910	1911	1912	1913
Lightning fires	158	84	110	282	206	804
Total fires	528	486	553	797	812	1,628
Per cent of total	29	18	20	35	25	49

Per cent for 6-year period, 34.
Average number per year, 274.

Fires Due to Human Action.

Fires from human causes have occurred as follows:

TABLE IV.—*Fires due to human action.*

Year.	1908	1909	1910	1911	1912	1913
Human-caused fires	370	392	443	515	606	824
Total fires	528	476	553	797	812	1,628
Per cent of total	71	82	80	65	75	51

Per cent for 6-year period, 66.
Average number per year, 526.
Average number of fires per year, all causes, 798.

We may expect, then, about 800 fires to start each year, 34 per cent of which can not be prevented. As the mountain population increases we may expect the number of fires to increase until such time as education creates a strong and unanimous public sentiment against fires in the forest.

Control Types.

In difficulty of control the National Forest areas of California are divided sharply into two types: The brush, where it is very high; and the timber, where it is comparatively low.

There are 19,340,000 acres classed as within the zone of Class A fire danger on the California National Forests. This classification includes all areas which require the service of regular paid protective officers in addition to the force required for administrative work, without deduction for small areas of no danger which do not effect the necessity for employing protective men.

These areas carry uncollected dividends in the shape of mature timber to the amount of $250,000,000. This can not be subjected to fires of any intensity without the certainty of some shrinkage in value. The soil capital is capable of producing a wood income to the amount of $2,500,000 a year. Something less than this will be produced with each acre burned over. There are high vaules at stake in forests which can grow the high-priced sugar and yellow pine. Our fire liability is therefore high.

Control Problem.

Our problem is to develop and maintain the organization and the facilities that, for the conditions we have stated, will keep the area burned over each year down to an accepted reasonable minimum. It is at once reducible to four main elements:

(1) The problem of protection finances, which seek to make proper distribution of fire combating resources between units of organization on the basis of their fire danger.
(2) The problem of indirect control, which seeks to reduce the number of fires.
(3) The problem of direct control, which seeks to assemble the whole field of available money, men, and facilities in the protection campaign up to the point of actual fire fighting, so that the minimum time will elapse between the start of each fire and the start of the fight.
(4) The problem of fire suppression, which seeks to put out every fire that occurs, with the minimum area burned over.

Protection Finances.

The problem of protection finances includes the finding of a measure of absolute protection needs for units of organization and its translation into money needs for each unit and the sum of the units. It includes the determination of the relative fire danger as between units for the purpose of furnishing a right basis of distributing funds between them. It should furnish in concrete terms the right relation between fire danger and protection costs. It must give true protection costs and enable us to see clearly the relation between protection costs and public benefits arising from protection expenditures. Since the assumption by each private owner of a share of the

protection cost necessitates a shift in our protection finances, studies to increase the cooperative protection comes within the problem of protection finances.

Indirect Control.

Under the head of indirect control come studies of the origin of fires for the purpose of developing methods of counteracting causes and preventing fires from starting. Compilation, classification, and study of origin statistics are necessary to show where prevention work must be concentrated. A study of the physical causes alone will not suffice; it must include a study of the psychological causes behind the physical acts, with a view to listing, each for its proper treatment, the mental attitudes of the various classes of fire setters. With the results of these studies before us, the next step is to devise intelligently the mode of written and personal appeal that will be most likely to reach and impress in favor of fire protection the minds of each class of fire setters. Corrective and punitive measures properly fall within the problem of indirect control, therefore the best principles of legislation and the methods of enforcing fire laws are a logical part of it.

Direct Control.

The problem of direct control has for its object the perfection of the control system, which is defined as all fire preventive facilities on a forest by reason of the expenditure of Government money. The purpose of the control system is to prevent as many fires as possible from starting, and to detect immediately each fire that starts and report its location to a member or members of the organization who will arrive at the fire in the least possible time, properly equipped to construct an effective barrier around it. The one best way of coordinating the control system will be found by studying and measuring the results gained under stated conditions by the use of its methods, appliances, and units in all possible combinations and groupings. The problem logically includes all studies in fire detection; in communication between the units of the system; in organization, equipment, and transportation of the regular and volunteer control forces; in reduction of inflammability before fires occur; and the types of appliances that will do all these things best. It includes the determination of the right relation of protection work to other National Forest work, and the proper reorganization of the total force when an emergency occurs.

Fire Suppression.

The problem of fire suppression comprises the organization and direction of all facilities for extinguishing fires from the time resources beyond the control system are needed until these resources are returned to their original position. It includes studies to secure the best possible personnel and organization of the volunteer suppression force, their speediest transportation to the fire, their highest efficiency on the line, and their immediate payment at the right rates.

CHAPTER IV.

PROTECTION FINANCES.

Ratio of Expenditures to Results.

The discussion in general terms of the public benefits which may be expected from expenditures of public funds in protecting public forests might be termed the philosophy of fire protection. Once having determined that large benefits are forthcoming, the problem immediately changes to one of plain business management. The duty is clearly laid on every officer in the Service by the public who hires him to secure the maximum of protection from every dollar expended for that purpose. The forest manager who will be judged the most efficient is not the one who can demonstrate mathematically how much more money could be used to advantage in protecting his forest, but the one who reaches and holds the protection standard on his forest for a constantly decreasing sum each year. It is not more money we want; it is more protection for the same money.

There is a best way to do everything—a way in which the most will be accomplished for a given expenditure of effort. There must be an ideal way to finance a fire-protection system composed of a number of units of organization on areas of varying degrees of fire danger. The ideal system of protection finance is not hard to state in theory, but it is immensely difficult to evolve a practical plan of operation from that theory.

Method.

Theoretically we assume a protection standard. We have done so—10 acres per fire for the timber zone; 100 acres per fire for the brush. Then we determine the cost per acre to meet that standard under conditions of fire danger found on the ranger-district area studied to give us a measure of fire-danger rating. Then, having rated the fire danger of the unit we are allotting money for, we arrive by simple proportion at its proper per-acre cost and multiply by the area of the unit. For example:

Take the ranger district described in Chapter II (p. 9) and assume that by applying proper weights we could reduce these factor ratings to a single rating of 140 and the district cost 3 cents per acre (to guarantee, with reasonable assurance, the average fire will not exceed the standard), then the other district described (p. 10), whose rating is 297 if the same set of weights is applied, would cost 6.4 cents per acre.

Applicability.

The method is impossible to apply at present for several reasons. (1) The 10-acre standard is entirely empirical; but until a sounder-based standard is devised no valid objection can be urged against its use. (2) Even supposing we can state fire danger in concrete terms, so far we have no known method of translating difficulties of protection into terms of cost to protect. While we know in general what steps must be taken to reach our standard of protection on a given area, we do not know this in terms of dollars per unit or cents per acre. (3) Rating the fire danger of the area units, an essential step in our process, has not been done. After the men in the field have had an opportunity to think along these lines and after the necessary field studies have been carried on, such ratings may prove feasible.

Present Policy.

In order to see where we are going, it is necessary to state just where we have reached at present with the ideas which rule protection finances. The district policies in protection finance now in effect are as follows:

1. Until wider knowledge is gained of reasonable standards of unit costs of both administrative and protective work, the total amount of money available for all classes of work on each Forest will remain more or less constant from year to year.
2. As such knowledge is gained, forest allotments will vary directly with the amount (number of units) of each class of work, the readjustments necessary to meet this variation being made gradually.
3. Reductions in administrative costs are made through handling the same business with less men, which means larger ranger districts and smaller yearlong roll.
4. Heretofore, statutory money not being convertible into funds with which short-term protection men could be hired, statutory reductions were accomplished either (*a*) through unfilled vacancies, or (*b*) concentration of surplus statutory men in winter work on other forests. Either or both of these methods may still be necessary.
5. Estimates for protection expenditures will be based each year upon an expected season of average fire danger. When less than average the surplus will be redistributed in the fall; when greater than normal the emergency will be financed by the district office.
6. Except for the reservation of necessary protection funds for May and June, the otal of the annual allotment available for protection will be planned for expenditure during the period from July 1 to the end of the fire season. The forest contingent should be designed to cover only small sums comprising forgotten items in the details of the supervisor's estimates of work to be done and the cost to do it.
7. The district contingent fund is designed to cover work all the reasons for which have arisen since the forest estimates were made. Fire emergencies will be handled with district funds on a per diem expense basis on telegraphic correspondence with the forests.

8. After the fire season each fall, the district forester will make a strict scrutiny of all protection balances, readjusting them if necessary.

9. Unexpended protection balances and statutory men not needed for the accomplishment of winter administrative work on the forests, will be subject to transfer to projects under the general direction of the district forester.

10. The total year-long force on a forest will be the absolute minimum number needed for a protection nucleus or to handle the current administrative work. Only in rare cases will the former exceed the latter.

11. Men, other than the permanent force, will be hired at a rate necessary to get the proper type for the best periods and for the length of time necessary to do the work that is to be done.

12. Improvement allotments will be made with the view of allowing all forests to proceed at a uniform rate toward completion of the projects called for in their protection plans.

Obtaining an Exact System.

General policies, even though they may be sound, do not constitute a rational system of protection finances; and while we may operate on them for the present it does not relieve us of the duty of establishing such a system just as soon as the knowledge on which it must be founded can be gained. We must know how many dollars must be expended in salaries and facilities to provide for a given area the degree of immunity from fire decided upon as our standard. The first step is to determine the fire danger of that area.

Assuming the standard sought to be the keeping of the average fire below 10 acres, the location of all fires for all years of which there is a record may be platted as a basis for the location of the control force. These must be placed in such manner that each fire can be reached in the elapsed time between its detectable size and the size at which it must be attacked to keep it from exceeding 10 acres. For example: Assume that on the Klamath the average fire must be reached by the first man when it is 5 acres or less in order to insure its control before it covers 10 acres. Assume that, on the average, between the time when it makes smoke enough to be seen by a lookout and when it covers 5 acres, two hours elapse, and that any guard can average 2 miles an hour through the country. Then no man should be stationed over 4 miles from a fire. Applying this to the map on which fires were platted will give the area limits within each of which a man must be stationed. His exact point within that area will be the one from which there is the lowest total travel time to the points at which all known fires have started. It is obvious that the application of this method must be made from study on the ground of every condition of topography, travel, view, community sentiment, and probable shifts in the risk.

But its results when available will give the salary costs for the protection of a given area. To these may be added the area's pro rata share of the forest's detection, communication, equipment, and overhead costs, from which its total protection cost per acre may be figured. The studies necessary to gain this knowledge will also furnish the basis for a fire-danger rating of the area.

When a great number of studies have been made of protection costs and danger ratings for areas of widely varying conditions, there will undoubtedly develop a more or less constant interrelation between the two, which, when fully worked out, will form the foundation of the determination of absolute protection needs and of a scientific method of protection finance.

CHAPTER V.

COOPERATIVE PROTECTION.

Cooperation Necessary.

The portion of the timber belt within the outside boundaries of the California National Forests is about half in public ownership and half in the ownership of private individuals and corporations, the holdings intermixed in blocks of irregular shape

and size, conforming to land-survey lines rather than to topographic units. Fire-prevention work can not be confined strictly to the area it is desired to protect. It must begin beyond its boundaries. The owner of a section of timber land can not expect to give it any sure degree of immunity from fire at a reasonable cost if he instructs his men to do nothing about any fire until it reaches the boundary of his section.

Exactly the same thing is true of the United States as a timberland owner. It should secure a uniform degree of protection on every acre within the timber belt in which the Government lands lie, in order to secure that same degree of protection for its own lands.

When an owner assumes the financial burden of protecting his own lands among a group of lands in different ownerships, but under a single protective system, his action means either an increase in the amount per acre being spent for fire protection for the group, or, if the total remains the same, a reduction in the amount per acre that the other owners spend. If one owner at the start assumed the entire financial burden of protecting the group and the other owners gradually took up their share, he would at first be paying the entire cost, and at the end, when complete cooperative protection had been accomplished, he would be paying an amount proportionate to the percentage his lands formed of the total area of the group. Each owner's contribution would entail a shift in the first owner's financial plans for the ensuing fire season. The United States is in the position of this first owner.

The Forest Service is proceeding on the assumption that by the combined push of public education, public opinion, and legislation this cooperation will eventually be effected.

Position of Private Owners.

The problem is to induce each owner of land in the forests to contribute toward its protection in an amount commensurate with the value of such protection to him. Here we can not apply the same measure of the value of protection as in the case of public-owned forests. The private owner, whether corporate or individual, has a period to his life. An income which, even though it is being produced each year, can not be collected until after his death has no value to him—in other words, it is not an income. The Government, on the other hand, having no period to its life, can afford to wait 150 years or any number of times 150 years to collect an income which has been accumulating at a low rate of increase during these periods. What is income to the Government, then, must be viewed as capital by the private owner. He has put money into the land and that money, *with interest*, must be returned to him within the period of his life—the shorter the period the higher the interest.

Money spent by private owners in fire protection must pay in terms of averting financial loss greater than the cost of protection within the life of the investment. What are such losses, how sure are they to occur, and what is an owner warranted in spending to avert them? These are the questions each owner must ask before he contributes to a protection system, and the officers of the Forest Service are the ones he may reasonably expect to answer them for him.

The typical timber owner (who, if he is not an operator, will eventually have a successor in interest who is one) has in the forest a mill worth $250,000, a transportation system and a logging system worth $300,000, and 400,000,000 feet of stumpage worth $1,000,000. The mill he can insure. By paying $3,750 a year he can absolutely protect himself against fire loss on this portion of his investment. As to the risk in his timber—for the last six years an average of 800 fires a year have occurred, scattered over 19,300,000 acres in the forests, or an average of one fire to the township every year. This average must be raised from the timberman's standpoint, for fires are not scattered evenly, but bunched around the activities which cause them. Logging is one of these activities.

The elements of possible loss are three—damage to equipment, loss of time, and lessening of log values.

In any one of these fires, if it is not controlled in its incipiency, he stands to lose through severe damage to cable, donkey engines, locomotives, buildings, hoists, and track. Furthermore, the work of 100 men the best part of a day may be necessary to control it. He has paid these men $275 to get out logs while they were doing something else. Consequently, his month's run of logs, say 5,000,000 feet, which should have cost him $8 per M at the pond, actually cost him $8.05 per M. Any lumberman, if shown, would gladly spend 1 cent per M to keep his logs from costing him 5 cents per M more.

Minimum Effect of Fires.

Studies were made by the Forest Service in the western yellow pine (white pine) forests of Oregon, east of the Cascade Mountains, to determine the actual effect on the value of standing timber of light surface fires—fires in the mature open pine forests that lick up the dry grass, needles, and small branches on the ground, but are popularly supposed to do no damage to standing merchantable timber. The following facts resulted from these studies:

1. The number of trees felled by such fires depends not on the severity of the fire and not on the amount of débris on the ground, but *upon the frequency of preceeding fires* which, having made butt scars, each succeeding fire enlarges. In an average area studied 6 per cent of the merchantable board foot stand was so felled by the last light fire. This fact is diametrically opposed to the popular theory that repeated light fires make for protection.

2. In the average forest of this character 45 per cent of the trees over 12 inches in diameter are fire-scarred at the butt. The larger the timber the greater the number of fire-scarred butts.

3. Following this timber through the mill it was found that from an average tract 19 per cent of the butt logs lost 16 per cent of their full scale each by reason of the fire scars, and this did not include those long-butted in the woods.

4. The value of practically all the fire-scarred butt logs was further decreased by reason of deposits of pitch around the scar averaging a 14-inch circle on the base of the log and extending 3 feet up. Each cut touching the pitch deposit was degraded from a possible 1 or 2 clear to a shop or box grade.

5. Summarizing: Ten out of every hundred logs from a mature sugar and yellow pine forest which has been run over by repeated light burns are worth, on the average, 25 per cent less money to their owner by reason of those fires.

This is the *average minimum* damage that every unprotected California timber owner is subject to. The possible maximum damage is well illustrated by the Widow Valley fire of July, 1910, in the open pine timber lands of Mr. T. B. Walker in the southwestern part of Modoc County, Cal. The fire covered 33,140 acres and was not fought outside the National Forest. As soon as it approached the boundary the Forest Service organized a fighting force which checked and held it just inside the National Forest. A careful estimate of the damage done by this fire was made by a timber expert in the Forest Service two years after the fire occurred—in order to give ample time for the forest to recover all it was going to. A total of 65,350,000 feet b. m. of privately owned timber was rendered valueless by this fire; 35 per cent of it was sugar pine worth $3 per M on the stump; 35 per cent yellow pine worth $2.50 per M; 26 per cent white fir worth $1 per M; and 4 per cent incense cedar worth $1 per M. The total money loss to the owner was $145,203. Eighty-eight thousand two hundred and eighty-three dollars of this loss was due directly to surface fire which *did not get into the crowns.*

Effect of Fires on Timber Bonds.

There is another financial aspect to forest protection from the point of view of the private owner of timber. The method of borrowing operating capital through a

bond issue secured by a mortgage on the properties of the operating company is coming rapidly into vogue in California. The uncut stumpage forms by far the greatest part of the security upon which the bonds are issued. Even assuming that the actual money damage done by the ordinary summer fires to sugar and yellow (white) pine timber in California is an academic question not yet definitely settled, the reports of these fires published by the Forest Service have an appreciable effect on the confidence of prospective investors in timber bonds. As a result of the 1913 fire season, inquiries as to the number and severity of the fires and the damage to timber done by them have been received by the San Francisco office of the Forest Service from investors in the Middle West and from representatives of bonding companies.

This waning confidence would be immediately restored if the bonded companies had upon their lands an effective fire-prevention system. What such a system can do is shown by the records of the Forest Service for the last six years. (Appendix 1.)

Any landowner or company whose holdings are within or adjacent to a National Forest can have its lands covered by the intensive protection system of the Forest Service at a cost to them of from one-half cent to 4 cents per acre.

Sample Cooperative Agreement.

In installing a cooperative-protection system on private lands the Forest Service prefers to operate under a very simple signed agreement. Both the Forest Service and the landowner want to know exactly how much money each party to the agreement is going to spend, in order to make the necessary financial arrangements. The methods, organization, and direction of the protective work must be thoroughly understood in advance.

The principles on which these agreements are drawn are:

1. The supervisor of the Forest submits to the owner a detailed plan of how the topographic control division or divisions in which the land lies are to be protected, together with a detailed statement of total costs and cost per acre.

2. The owner accepts it, it is modified at his request, or he rejects it, in which case there is no agreement.

3. The owner, if the protection plan is acceptable, deposits with his own agent (usually a local bank) a sum equal to the cost per acre times his acreage in the protection unit.

4. The owner deposits a further agreed-upon amount (from $300 to $1,000, depending on the risk and area) to cover his share, on an acreage basis, of emergency fire-fighting expenses. The Forest Service assumes any excess, on the ground that a serious conflagration is a public calamity. If no fires occur that the standing protection force can not handle, the emergency deposit is returned to the owner.

5. All permanent improvements, except roads, trails, and fire lines (telephone lines, cabins, tool caches, etc.), called for by the plan are built at the expense of the Forest Service, because it is impracticable to share ownership. The owner donates necessary rights of way and sites.

6. The control of the standing protection force is absolutely with the forest supervisor. It must form an integral part of the Forest protection organization.

7. Bills against the owner for items specified in the plan are paid by the owner's agent on vouchers audited and O. K'd by the forest supervisor.

8. At the end of the fire season the supervisor renders the owner a detailed account of expenditures under the plan and a report of the fires and the damage (if any) done his timber.

Several such cooperative agreements are in effect on the National Forests in California, costing the landowners from 1½ cents to 3½ cents per acre per year. A great many fires have been handled in their incipiency under all of them, and no material damage has occurred on any of the lands covered.

CHAPTER VI.

CAUSES OF FIRES.

Cause Statistics.

The first step in the study of causes is to analyze them on the basis of past history. If data relating to causes are available over a sufficiently long period of time and the population and their ideas on fire remain more or less fixed, we can reasonably expect that history will to some extent repeat itself. If this is so, the causes most demanding removal can be concentrated upon.

Cause statistics for the California National Forests are available for the last six years, from 1908 to 1913, inclusive. Prior to 1911 their accuracy is doubtful. Their importance was not realized and the organization of the field force had not developed sufficiently to secure them. However, it is entirely probable that as many camper fires were missed as sawmill fires, and the proportion of the numbers from each cause to the total each year is fairly dependable. Beginning with 1911, with the introduction of a competitive fire prize, the accuracy of cause reports increased greatly, and for the last three years the figures are near enough to the truth for any purpose to which we may wish to put them.

Table V shows the causes of fires on and adjacent to the forests originating from human agencies for the last six years, assuming all lightning fires known:

Table V.—*Causes of fires originating by human agency.*

Causes.	1908.	Per cent.	1909.	Per cent.	1910.	Per cent.	1911.	Per cent.	1912.	Per cent.	1913.	Per cent.	Total.	Per cent.	Average.
Railroads	12	4	22	5	11	2	24	4	93	15	64	8	226	7	38
Brush burning	17	5	37	9	29	7	38	7	42	7	78	8	236	8	39
Campers	108	29	99	25	63	14	71	14	98	16	214	25	648	21	108
Sawmills	.....	.....	14	4	11	2	15	3	29	5	46	5	115	4	19
Incendiary	13	4	17	5	59	14	92	18	71	12	133	18	398	12	66
Unknown	103	28	152	30	204	46	195	38	190	31	178	22	1,022	32	170
Miscellaneous	117	30	51	13	66	15	80	16	83	14	111	14	511	16	83
Total	370	100	392	100	443	100	515	100	606	100	824	100	3,150	100	526
Per cent of increase over previous year.	.....	.....	.....	7	.....	13	.....	16	.....	18	.....	37	......	[1] 125	....

[1] Including 6 years.

A study of this table gives the following conclusions:

1. The total number of man-caused fires has increased remarkably from year to year for the last six years. Two and a quarter times as many occurred in 1913 as in 1908.
2. Beginning with 1911 there has been a consistent decrease in the number of fires from unknown causes. We still (1913) know the cause of only four-fifths of the fires, and on an average for the last six years we know the cause of only two-thirds of them.
3. The proportion of fires from miscellaneous causes (except in 1908) has remained low and remarkably consistent.
4. The proportion of fires caused by those having industrial interests in the forests (railroads, brush burning, and sawmills) is low as compared with those set by the transient class (campers and incendiaries).
5. Lumbering operations, popularly believed to be the cause of a large proportion of the fires, are the least dangerous cause; having remained consistently low for six years and averaging only 4 per cent of the total.
6. The result of the general use of oil as railroad fuel is clearly shown. Except for 1912, which is clearly out of line, railroads have caused only a small proportion of the fires.
7. Land clearing is not a very prolific cause of fires.
8. The mountain traveler and the incendiary, taken together, set, on the average, a third of all our man-caused fires.
9. The number of camper fires has shown a decided increase in the last three years.
10. So have incendiary fires. Making due allowance for increased travel, some influence within that period has increased carelessness with fire in the mountains.

Standard Classification of Causes.

In order that each cause may be reported under its proper heading, a standard classification of causes must be adopted. It will not do for a fire set from a cigarette dropped by a hobo hiking up the Southern Pacific tracks in the Sacramento Canyon to be reported as a railroad fire from the Shasta while a fire from a similar cause near Truckee is reported by the Tahoe as a camper fire. Neither should the present classification be changed. Its form must be retained in order to secure comparisons over a long period of time, in order to see whether the proportion of fires from any one cause is increasing or decreasing. We can, however, adopt as standard the heading now in use under which each fire will be reported. This standard subclassification may be amplified from time to time as found necessary. Bearing in mind the purpose of cause records—the counteraction of those causes—the basic principle should be to list the fire with the activity in connection with which it occurred. For instance, if a lumberjack sets a fire with a cigarette while employed in logging, it would be reported as a "sawmill" fire. If the same lumberjack goes fishing on Sunday, and, during his rambles, drops a lighted match and causes a fire, it would be reported as a "camper" fire.

The following subclassification of causes will govern for District 5:

Railroads:
- Sparks from smokestack.
- Sparks from fire box.
- Matches or tobacco thrown from trains.
- Fire escaping in any manner from section gangs; telegraph or telephone line crews working along the right of way; bridge or other railroad construction or repairs crews.
- Fire caused by trackwalkers—whether railroad employees, tramps, or migrating laborers.

Brush burning:
- Fire escaping from clearing land for all agricultural purposes—cultivation, fencing, placing beehives, buildings, or ditches, or irrigation reservoir sites.
- Fire escaping from clearing land for power purposes—power-reservoir sites, transmission lines, power-house sites, conduit and pipe lines.
- Fire escaping from power-construction crews at work or in camp.
- Fire escaping from cleaning up and burning litter about small towns and mining camps.
- Fire escaping from smoking out animals, insects, or reptiles.

Campers:
- Fire caused in any accidental manner (unextinguished matches, tobacco, or camp fires) by travelers in the mountains for recreation purposes, hunting, or fishing, whether on foot, horseback, by wagon, or automobile.
- Fire caused in any accidental manner by other travelers, stockmen, prospectors, business men, etc.

Sawmills:
- Fires occurring in connection with lumbering operations, whether from individual members of any crew, from donkey engines, logging railroads, sawmill engines, woods camps, traction engines, or hoisting engines, or blasting in connection with logging.
- Fires caused in any accidental manner by woodchoppers, shake makers, pole or post cutters, or free users.

Incendiary:
- Fires calculated to spread, intentionally set by persons from any motive, good or bad. Under this head would be included light burners, Indians, prospectors (when they intentionally burn off cover), drunks, lunatics, children, hunters (for the purpose of driving game), as well as the malicious incendiary.

Miscellaneous:
- Fires which do not come under any of the foregoing heads—spontaneous combustion, or bottles (if any occur), fires escaping from burning buildings or automobiles, short-circuited electric wires, etc.

Classification by Motive.

It will immediately be seen that there is another possible basis for classification of causes—the psychological or motive classification. When a man touches a match to a clump of dry brush and a forest fire results, there is a physical action—the mechani-

cal cause of the fire; but the cause of the fire contains another element—the psychological background for the physical action, the mental processes, the activity in the man's mind which preceded the act and resulted in his setting the fire. He may have wanted to make trouble for a ranger, or to smoke out a hornet's nest, or he may have been drunk.

In any case, the sum of his mental processes constituted a state of mind or mental attitude which in the above cases took the form of hate, desire for comfort, or irresponsibility. The true object of fire-reduction work is to create—through change from their present form—mental attitudes that will not result in the physical act of setting fires.

Fire Setting from Self-Interest.

Classified according to the mental attitude of those who cause them, fires are set for three reasons: Self-interest; carelessness, or thinking of something else; and irresponsibility. The timber-land owner who sets a fire for the purpose of consuming the inflammable ground litter in order that his merchantable trees may not deteriorate in value through an accidental fire is acting from the motive of self-interest in exactly the same way as does the Hoopa Indian who sets a fire to singe the grasshoppers' wings in order that they may be more easily collected for soup. The cowman who fires his range to clear out the "brush" which is often young pine and fir; the settler who sets fire to the chaparral in order that next winter's clearing may be easier; the prospector who fires a sidehill to uncover the mineral soil—all these are acting from self-interest. So, too, with the malicious incendiary. His self-interest, while it may not be financial, is the strictly selfish motive of feeding a private grudge, revenge for a personal wrong, or even the satisfaction of a grim humor in "seeing the rangers work." This whole class requires that their mental attitude be changed for one that will not result in fire setting.

Fire Setting from Carelessness.

The mountain tourist who breaks camp in the morning and leaves without putting out his camp fire does not do so because he wants the forest burned over. He does so because he "forgot" to put it out; because his mind was so full of packing his camp equipment and saddling his horses and of looking forward to the rest and smoke he would have when once on the trail that the duty of extinguishing his camp fire was crowded out of his mind altogether. We describe the flipping away of a cigarette as a "thoughtless act." It is, because it is generally done while the mind is entirely occupied with something else. Children playing at Indians in the brush light a fire merely as an accessory to their play, not for the purpose of burning over the country. The fire is a relatively unimportant part of what their attention is absorbed in. In dealing with this class, no particular change in mental attitude is necessary; what is necessary is to insure that their mental state shall *include* the thought that unextinguished fires are dangerous.

Irresponsible Incendiaries.

The irresponsible class—drunks, lunatics, and idiots—have no logical mental processes, and little can be done about them except to shut them up.

Changing Dangerous Mental Attitudes.

The only tool with which mental attitudes can be changed or directed is education; for our purposes, by written appeals and by personal contact. Any attitude is the aggregate of a multitude of impressions, and it can be changed or directed in the same way it was formed, by consciously preparing impressions for it and delivering them in such way that they can not fail to be received. These consciously created impressions should be designed to utilize as far as possible the mental attitude already existing in the man to be reached. To one who sets fire from self interest, for example, there may be gradually created in his mind the impression that it will be still more to his interest to keep fires out of his timber, or that there is a still easier way to catch grasshoppers, or that the rangers get extra pay for fighting fires. Fear of personal injury,

of financial loss, of imprisonment—itself a motive of self-interest—may be used to counteract causes originating from this motive.

The opposite of self-interest—altruism—may be used in counteracting thoughtlessness. For fires are often set by the very best type of citizens who "if they had only thought" would never have done such a thing. Our task is to see that that thought is supplied at just the time when its presence will mean one less fire.

CHAPTER VII.

EDUCATIONAL WORK.

Object of Study.

The object of a study of educational work in connection with fire protection is to determine who must be reached, and by what message, and where and how that message must be presented. The first classification of causes in the preceding chapter shows us who sets fires; the second, why fires are set. Here the cause study ends and the work of the educational expert begins.

How to Reach the Public.

His problem is to devise the material for an appeal to the public, which may be either spoken or written. General information about fire damage and fire control, given the widest possible circulation, will accomplish much, but it must be supplemented by specifically directed appeals. These appeals require an analysis of who sets the fires, and why; how best to supply the thought necessary to counteract the fire-causing tendency; through what medium; and where this can be done with most effect. For simplicity and usefulness, such an analysis may take the form of a systematic tabular statement. (Table VI.)

Cards and Posters are Best.

From this table it will be immediately seen that the medium through which we must reach practically every class which can be expected to read is signs, cards, or notices. For this reason it is necessary to study the mechanics of the preparation and presentation of those notices to determine the most efficient.

The best way to reach the traveling public when it is traveling is by signs. Signs, in this sense, include all such things as fire warnings, posters, showing the six fire rules, reward notices, bulletin boards, or any other kind of matter posted for general public reading. The purpose of the sign is, first, to attract the attention of the passing traveler; and, second, to convey to him an impression that he must use care with fire.

William James, in his "Psychology," distinguishes two kinds of attention: Immediate and derived—the first when the stimulus is interesting in itself, and the latter when it owes its interest to *association with* some other immediately interesting thing. He says further that if we wish to keep someone's attention upon one and the same object we must seek constantly to show him something new about it, and "there is no such thing as voluntary attention sustained for more than a few seconds at a time." Few signs can be devised which are highly interesting in themselves; therefore, the interest must lie in the associations called to the mind of the reader. Also very many variations of the same theme must be used. We get then three principles for the subject matter of forest signs:

1. They must serve as a connecting link between something of interest to the reader and care in handling fire.
2. The message must be delivered in a short space of time.
3. The method of delivery must be constantly changing.

The old cloth fire-warning sign contained none of these principles and attracts little more attention than a knot on a tree.

Persons traveling horseback or afoot on mountain trails usually do so at about the rate of 3½ miles an hour. This means they are moving forward at the rate of 5 feet a second. Presupposing a clear view, an object (a sign) by the side of the trail will remain in the forward quadrant of vision longer the farther it is from the trail; but the

TABLE VI.—*An analysis of five causes and means for their prevention.*

Who sets the fires.	From what psychological cause.	How best supply the "care with fire" thought.	Through what medium.	Where.	Remarks.
Railroads:					
Engineer; fireman	Mind taken up with operating engine and watching track.	In connection with ideas on operating machinery.	Signs, and articles in technical journals.	In the cab, the roundhouse, and the railroad-men's clubs and eating houses.	The "company attitude" having great influence on the attitude of its individual employees, the supervising officers of each department should be appealed to from the altruistic and "public approval" standpoint.
Passengers	Mind taken up with reading or watching scenery, etc.	In connection with something to relieve the tedium of travel, or with preservation of scenic beauties being passed.	Time tables, signs, cards, and reading matter, roadside signs.	On the train through the news service, and through literature in library and observation cars.	
Employees on track and right of way work.	Mind taken up with their work.	In connection with ideas on their work.	Signs, reading matter, track patrol.	Through gang foremen and along right of way on telephone poles, bridges.	
Track-walkers other than railroad employees.	Mind taken up with getting to destination.	In connection with distances and industrial conditions in towns, "Labor wanted."	Signs, track patrol	Along the right of way	
Brush burning:					
Settlers	Desire to remove difficulties in the way of developing their land.	Fear of penalties for burning land of others, or easier ways of safely burning his own; knowledge of soil loss; "you can't make humus out of smoke."	Personal talks and assistance. Articles in local papers and papers in agricultural journals.	On the road or at post office. In his market town.	The brush is an enemy to the settler. We must show him that brush, when it retards useful development, is our enemy too.
Power company employees.	Mind taken up with completing work in hand.	Fear of jeopardizing progress of work in hand.	Permit clauses, signs, letters; articles in engineering journals to reach officers of company, and by filtering down to their employees.	Through construction foremen. In camps on the works.	Possibility of delaying work tactfully presented to officers of company will tend to develop proper "company attitude."
Residents of small towns and campers.	Mind taken up with destroying refuse.	In connection with civic pride "Clean-up day."	Signs, and through town authorities.	In post office and along streets.	
Smudge builders	Desire to get rid of noxious insects or animals.	In connection with the equal undesirability of fires.	Signs	Near yellow jackets' nests and bee trees, or in mosquito-infested areas.	If rangers will tell a settler where a bee tree is, the settler knows that the ranger knows who smoked it out and will use care.
Campers:					
Health or pleasure seekers.	Mind taken up with traveling or preparing to travel, and interesting things along route.	In connection with distances with overlooked baggage, with attractive camps for others, with preserving scenery, including where to go, what to take; personal responsibility.	Signs, cards, pictures, maps, registers, booklets, useful articles in camp, newspaper and magazine articles.	At their homes, at outfitting points, in railroad stations, livery stables, garages, resorts, and road houses; on the trail; at camp grounds.	A sense of obligation to the Service on the part of the camper is a much better deterrent than fear of punishment.
Travelers on business	Mind taken up with their business and reaching destination.	In connection with their business.	Signs, cards, letters, permit clauses.	On the trail, at point of starting and destination.	

Sawmills:					
Woods employees	Mind taken up with getting out logs as rapidly as possible.	In connection with loss of logging time in extinguishing fires. By making freedom from fire one of the elements of efficiency of the operation.	"Camp rule" signs, personal talks in woods, demonstrating costs of fires.	In the woods, in the camps, on marked trees.	The "company attitude" has more influence in lumbering than in any other industry. Show the manager that fires cost money and the lack of them saves it, and the right attitude will follow.
Donkey-engine crews	As above; raising hood to increase draft.	Comparison of time saved with increased draft and lost in extinguishing fires.	Signs, personal talks	At donkey settings	
Blasting crews	Mind taken up with getting back to spot after blast is discharged.	Make them think of possible fires immediately after the noise—"Bang! Did your blast set a fire?"	Signs	Along railroad grades under construction.	
Logging railroad crews	Mind taken up with getting to the pond with the load.	In connection with loss in running time, connecting heavy grades, and the fire idea.	Cards, signs	Along logging railroads	
Incendiary:					
Light burners	Desire to protect their property.	In connection with protecting property in more efficient and less dangerous way.	Articles, talks, cooperative fire line burning.	Newspapers and magazines	The whole phenomenon of the general acceptance of the light-burning theory shows how it is possible to make a public mental attitude.
Indians	To get food or materials for industries.	Cautionary warnings, or even coercion, through agent. Show a better way to accomplish same object.	Talks and demonstrations	In the woods	
Prospectors	To promote their business	Coercion through recourse to law. Relative values of young forest and poor prospect.	Surveillance, talks	do	
Malicious incendiaries	Revenge or mischief	Study to find out whether fancied wrong is not a real one which may be righted.	Talks	do	As long as there exists a state of mental feud there can be no meeting of minds, no change in attitude. A friendly visit may put a stop to an incendiary's activities.
Irresponsibles	Wantonness	Fear of imprisonment	Patrol and local authorities	do	

farther it is from the trail, the larger must be the type—to insure reading within the time it is in view. So a maximum limit of distance is soon reached on account of size of type; and a minimum limit of distance exists on account of lack of time.

Rules for Sign Lettering.

The following are the results of experiments undertaken to determine the optimum distance from the line of travel a sign should be placed and the size of type and number of words that can be used:

TABLE VII.

Traveling at 5 feet per second—			
Distance of sign from line of travel.	Number of seconds in which it is within easy reading vision.	Minimum length of letters easily read.	Number of words averaging 5 letters each easily read.
Feet.	*Seconds.*	*Inches.*	
5	1½	½	10
7½	2¼	¾	12
10	3	1	14
12½	3¾	1¼	16
15	5	1½	16
20	5½	1¾	14
30	6	2	12

From this table it is seen that very small type requires a short distance, and with the consequent brief reading time only a small number of words can be used. On the other end of the scale the type is so large and the words take up so much horizontal space that, in the time allowed, the number of words that can be easily read is again reduced. This indicates that for this rate of speed the optimum sign should be placed 12 to 15 feet from the line of travel, and contain not more than 14 to 16 words in 1¼ to 1½ inch type. For travel involving other rates of speed (automobile, etc.), other limits will, of course, be necessary. These can be found by simple experiments.

We may have a message to convey which requires a comparatively long story; one that entirely loses its carrying power if shortened to a few words. Such signs should be posted at points where the traveler must necessarily stop and preferably where he stops rather against his will and has nothing to do while waiting—at watering troughs or fords, for instance. For these signs, too, there is a right relation between reading distance and size of type which can easily be worked out by simple tests.

Each sign must attempt to drive home one good point, and the reader's mind must be pinned to one good argument without distraction. Each must have dignity, clearness, force, and pertinent contents. The value of the sign method of creating a mental attitude lies in the series of single impressions made upon a great number of individuals.

Variety is one of the essentials of effective signs, and the greater the number of men who are engaged in designing them the more likelihood there is of securing variety. Supervisors are authorized to have card notices printed locally, and hereafter will design and secure their own in accordance with the above principles. The district office will act as a clearing house and critic of sign material (which will be sent in for information) and will keep the field supplied with information and suggestions.

Appeal Through the Press.

The periodical publication, be it the local newspaper or the trade or professional journal read by a specific class of readers is, after all, the one medium of information seen and read by the greatest number of persons. Its attitude toward the policy of fire protection carries further than that of any individual. Forest officers, therefore, should constitute themselves a source of information to the local papers, and should

aim to acquaint them with the harm wrought by fires, with the essential facts about fire protection, and with the reasons for it.

Notices of all public steps taken in carrying out protection plans should be furnished the papers, as well as figures of actual losses when fires occur, and results accomplished through protection, and the names and circumstances of convictions for setting fires.

Merely "general stuff" about forest fires fails of its purpose just as surely in published prints as it does elsewhere. The appeals must have a target, and be aimed at that target to be effective.

Other Forms of Written Appeal.

The chief element of value in useful articles supplied to mountain travelers as a medium of the written appeal is the cumulative effect that their continued presence produces on the minds of a few persons. An essential of their make-up is, therefore, that they must serve a purpose so useful to the particular persons we wish to reach that they will not throw them away. In view of the necessity of the authorization of the purchase of each article by the Secretary these will continue to be handled by the district office.

The very presence in the Forest of Forest Service equipment—a tool box, a ranger station, or a shovel hanging up at a camp ground—serves as a means to convey by inference and an appeal to the imagination the "care with fire" thought. This is a method which is highly effective, and has been taken advantage of but little. A tool box, unexplained, may be passed by a hundred travelers without one of them noticing it particularly or connecting it with fire protection. A box with the sign "U. S. Forest Service Fire Fighting Tools," immediately conjures up to the imagination the mental picture of the fire and the Forest rangers fighting it. Through association it is extremely likely to awaken the thought "I must be careful of my camp fire."

Personal Appeal.

The protection of the forests entails carefulness with fire in the woods on the part of travelers. The spread of this ideal of carefulness might well become the purpose of a science of "personal appeal." The potentialities of the personal appeal may be realized if we stop to think that during the 122 days of an average fire season we have in the neighborhood of 900 men in the woods. If each man met two people each day and impressed care with fire upon them in exactly the right way, 219,600 people would be so impressed.

Clearly, a study is needed to find out exactly the right way. None has been made, but proceeding on the premises of accepted facts about human nature, a few principles governing methods of personal appeal may at least be deduced.

The average man has certain attributes—certain likes and dislikes—and, as each one of us conforms to the average up to a certain point, by a study of our own characteristics we may define those common to the average. By determining what to appeal to we may be able to state in general terms how best to do it.

No man likes to be talked down to. The assumption of intellectual superiority at the start by a forest officer tends to antagonize those with whom he talks. This is why a show of authority, three badges pinned on a suspender, an officious manner, or direct contradiction of statements, make a ranger unpopular and lessen his usefulness. The best manner to assume is one of intellectual equality with the man whom it is desired to impress. Be interested in the same things with him.

Each group or community has an intellectual leader, whether the community knows it or not. In a community given over to the theory of light burning there is generally some one man whose state of mind on that subject largely controls the community opinion. If that man is converted, the whole community is likely to change its viewpoint.

A spirit of courtesy and friendly interest in others should be given its natural expression in full appreciation of anything well done. Most men, very rightly, take great pride in their work and are very willing to listen to praise of good work done. Not only should we record by letters the Service's appreciation of good work done at a fire, but a remark to a stranger like, "That's a mighty good-looking pack you've got on that horse" may be the first mental step toward persuading that stranger to bury his fire next morning.

Earnest, whole-souled effort in any body of men all working for the same thing is in itself impressive. If the public is shown that *we* think we are right beyond any shadow of a doubt, they may be willing to listen to what we think we are right about.

Curiosity is a human trait sufficiently general to be taken advantage of. Lookout stations can be used, first, to excite curiosity; then to gratify it. Attract attention to the lookouts; point out the trails to them; let the lookout men explain their methods and the reasons for them; have a register at the station; have picture postals of the station, with a mail box outside the door. Other phases of Forest work can be made to excite just as much curiosity. The right kind of a remark casually dropped about a queer-looking hole in the butt of a tree may make the stranger ask "Why?" And this is what we want.

Appeal Through Many Traits.

One of the main elements of value in furnishing a useful article is to furnish at the same time an opening for the personal appeal, through the general trait of gratitude, appreciation of favors received. Another way in which this trait can be utilized is taking the name and destination of a camper and telling him that in case of emergency a message to him or from him will be dispatched by Forest Service phone lines or messengers.

Once reach a man's sense of responsibility or put him on honor, so to speak, and the chances of his camp-fire escaping are materially lessened. This is exactly the trait the campers' register appeals to if the invitation to register is presented in the right way. If, in visiting a camp, the ranger glances around and says, "Well, I see you're an old-timer in the hills. I don't have to worry about your fire," the chances are that he will not, even if the man happens to be in the woods for the first time.

Many campers like to have the Forest ranger drop into their camps from a sense of companionship, interest in meeting new people, or even from that slight flavor of romance that lingers around the title of Forest Ranger. If they like it, give it to them—and then use it.

In small isolated communities social gatherings are an intellectual necessity. A talk by a forest officer, illustrated by lantern slides or moving pictures, followed by a dance or a supper organized by the forest officers' wives may result in a changed community sentiment.

Principles of Personal Appeal.

From the foregoing we may derive the following broad principles, from the use of which we may expect better results in personal appeal for care with fire in the forests:

1. The man addressed should be met on terms of intellectual equality.
2. Effort should be concentrated on the intellectual leaders of a group or community.
3. Appeal may be based on the pride of a man in his work.
4. The sincerity of purpose of the forest officer may serve as a basis of appeal.
5. Advantage may be taken of the traveler's curiosity.
6. Advantage may be taken of the traveler's gratitude.
7. Advantage may be taken of the traveler's sense of responsibility.
8. Advantage may be taken of the traveler's sense of adventure.
9. Advantage may be taken of a community's need of social intercourse.

There is no doubt whatever that maximum efficiency in preventing fires through personal appeal is not being reached. Opinions differ, especially among rangers, as

to the wisdom of accosting all strangers. This will be no longer a matter of opinion but a clearly defined district policy, and every forest officer will use every opportunity to secure care with fire in woods, through personal appeal. Judgment and results along this line will be as much a part of his work, on which his efficiency will be rated, as judgment and results in other phases of fire-protection work.

A considerable amount of time is lost by new men in getting effectively under way in this work. Seldom is this entirely their fault. The supervisor and the district ranger know the public with which a new patrolman will come in contact better than he does. They should give him that knowledge to work with just as far as possible. Written guides, at the beginning of the season, telling whom he will meet, how to address each class, what to talk about, and giving effective openings for introducing the subject of fire prevention may increase the patrolman's power fourfold.

CHAPTER VIII.

INVOKING THE LAW.

Legislation.

When the education of the public reaches the point where the majority of the community feels that every member of it must do certain things and must not do certain other things a law results. It is the general practice of the representatives of the public who are intrusted with the actual making of the laws to call in for advice such experts on the study as are available while the process is going on. The Forest Service, being recognized as an authority on fire protection in California, has been called upon to render such advice. And it is possible that in the framing of county or town ordinances on fire protection the field officers of the Service may be consulted as experts. Such advice should be given fully and freely when asked for.

In forest legislation by any political unit, whether it is the nation or the county, certain guiding principles should hold, and as these have been thoroughly worked out and concurred in by authorities on the subject they are stated here:

1. Centralized control of forest work, either in a special board or one man.
2. One properly trained executive head responsible to the controlling board or man.
3. A statement of policies only, not administrative details, that the executive head is to work out.
4. Sufficient authority and money to enable him to employ and embody with police powers a field force, however small.
5. Sufficient authority for him to furnish the field force with the facilities necessary to carry on their work.
6. Provision to encourage cooperative protective patrol by private landowners.
7. Provision for the payment of protection expenditures on an equitable basis by both parties in interest; the community and the landowners.

The importance of vigorous prosecution for violation of fire laws has often been mentioned. Too much emphasis can not be placed on the value of the prosecution of criminal offenders as a deterrent to others with fire-setting proclivities.

The Federal Fire Law.

The Federal fire law is as follows:

Whoever shall willfully set on fire, or cause to be set on fire, any timber, underbrush, or grass upon the public domain, or shall leave or suffer fire to burn unattended near any timber or other inflammable material, shall be fined not more than five thousand dollars, or imprisoned not more than two years, or both. (Sec. 52, act of Mar. 4, 1909.)

Whoever shall build a fire in or near any forest, timber, or other inflammable material upon the public domain shall, before leaving said fire, totally extinguish the same; and whoever shall fail to do so shall be fined not more than one thousand dollars, or imprisoned not more than one year, or both. (Sec. 53, act of Mar. 4, 1909.)

This law defines the following offenses:

1. Willfully setting on fire timber, etc., upon the public domain.
2. Willfully causing to be set on fire timber, etc., upon the public domain.

3. Leaving a fire or allowing one to burn unattended near any timber or other inflammable material (on public domain).

4. Building a fire in or near any forest, etc., upon public domain and leaving it without totally extinguishing it.

The offense of setting fire to timber, etc., on the public domain may be committed even if the fire is started on adjoining private land. Judge Wellborn, in his charge to the jury in the case of United States *v.* Henry Clay, stated as follows:

You are further charged that it is immaterial whether the fire of October 19, 1909, mentioned in this indictment, originated on private land if it was set willfully, and if in the course of nature and in view of all of the surroundings the said fire would reasonably be expected to be communicated to the public domain. A man has no lawful right to set fire to his own property, if he has reason to believe or intends that such fire will be communicated to the property of others and destroy it.

With respect to the meaning of the word "willful" in section 52 above quoted, Judge Whitson's instructions to the jury in the case of United States *v.* Fisher, fire trespass on the Colville National Forest, are as follows:

And, as to the third count, whether he willfully set on fire or caused to be set on fire the timber, slashings, or grass there growing. It is charged in the third count, that the act was maliciously done; but it is not necessary, under the statute, that malice be shown. It is necessary to show that the act must have been willful; that is, intentional. Not with intent, however, to burn the public domain, and destroy property, but purposely built the fires or purposely left it unattended or purposely failed to extinguish it. The purpose does not apply to the result, but to the acts charged, for one willfully, knowingly doing an act is presumed to intend the consequences which naturally may be expected to flow from such an act.

The State Fire Law.

The California State law relating to forest fires amended by the 1911 session of the California Legislature provides that violations of the provisions of the act shall be a misdemeanor and punished by a fine of not less than $50 nor more than $500, or imprisonment in the county jail not less than 15 days or more than 6 months, or both.

Subsections 1, 2, 3, and 6 of section 384 of the Penal Code are as follows:

1. Setting fire, or causing or procuring fire to be set to any forest, brush or other inflammable vegetation growing on lands not his own, without the permission of the owner of such land; provided, that no person shall be convicted under this section who shall have set, in good faith and with reasonable care, a back fire for the purpose of stopping the progress of a fire then actually burning.

2. Allowing fires to escape from the control of the persons having charge thereof, or to spread to the lands of any person other than the builder of such fire without using every reasonable and proper precaution to prevent such fire from escaping.

3. Burning brush, stumps, logs, rubbish, fallen timber, fallows or grass on his own land, or blasting with dynamite, powder, or other explosives, or setting off fireworks in forest or brush covered land, either his own or the property of another, without taking every proper and reasonable precaution, both before the lighting of said fire and at all times thereafter to prevent the escape thereof; provided, that any fire warden may, in his discretion, give a written permit to any person desiring to burn or blast as aforesaid. Each permit shall contain such rules and regulations for the building and management of such fires as the State board of forestry may from time to time prescribe; and in any prosecution under this subsection it shall be prima facie evidence that the defendant has taken proper and reasonable precautions to prevent the escape of such fire, when he shall show that he has received such a permit and has complied with all the rules and regulations therein prescribed.

6. Leaving fire burning or unextinguished on departing from a camp or camping place, or allowing such fire to spread after being built.

The State law defines the following offenses:

1. (*a*) Setting fire to any forest, etc., growing on lands not his own without permission of the owner of such land.

(*b*) Causing fire to be set to any forest, etc., on lands not his own without permission of the owner.

(*c*) No person shall be convicted of offenses *a* or *b* who shall have set a back fire in good faith to check a fire already burning.

2. (*a*) Allowing fires to escape from control to the lands of another person without using every reasonable precaution to prevent such escape.

(*b*) Allowing fires to spread to the lands of another person.

3. (*a*) Burning brush, etc., on his own land without taking every reasonable precaution to prevent the escape of fire.

(*b*) Blasting with dynamite, etc., in forest or brush-covered land, either his own or the property of another, without taking every reasonable precaution to prevent escape.

(*c*) Burning permit and compliance with the regulations contained therein shall be prima facie evidence of reasonable and proper precaution to prevent the escape of the fire.

6. (*a*) Leaving a fire unextinguished on departing from camp.

(*b*) Allowing a camp fire to spread after building.

Invoke the Proper Law.

The question naturally arises at the time a fire trespass is discovered, Shall action be taken, and if so, under the State law or under the Federal statute? Cases may arise which do not come within the province of the Federal statutes and can not be prosecuted thereunder, and therefore must be taken up, if at all, under the State law. For example: A is burning brush on his own private land and a spark escapes to Government land causing a fire. A has not willfully set this fire with any intention other than burning the brush piles on his own land. He has no reason to believe, nor did he intend that such fire will be communicated to the property of others. He has not left the fire to burn unattended, and he has not built the fire and before leaving it failed totally to extinguish it. In such a case he could not (and should not) be prosecuted under the Federal statute. On the other hand, under subsections 2 and 3 of the State law, above quoted, a prosecution might be commenced with a reasonable prospect of success, if he did not take every reasonable precaution to prevent escape of the fire.

The attitude of State or county officials is also a factor of importance in deciding between State or Federal law. Forest officers should know whether the active interest and cooperation of State and county officers can be expected. If quick action in prosecution and conviction is desirable and the State law may be expected to act more rapidly, use that law provided the active cooperation of the county attorney can be secured. But, as a general rule, subject to the foregoing instructions, resort to the Federal law is preferable in every flagrant case. It is common knowledge that tampering with the mail is an offense against Federal law and punishment is so sure and severe that train and stage robbers often leave mail sacks alone because of their respect for the strong arm of the Federal Government. In time we may be able to handle fire cases so as to inspire a similar respect for Federal fire laws.

The offenses of allowing fires to escape from the control of the person having charge, or of allowing fires to spread to the lands of another person, *without using every reasonable and proper precaution to prevent such escape*, should be taken up with the State authorities since the Federal law does not include them. This would not be true if the fire was willfully set with the purpose of communicating it to other land. This subsection (2 of the State law) embraces fires lawfully set on public domain or State lands and also fires lawfully set on private land.

Subsection 3 has about the same scope as subsection 2, with an additional proviso that a permit and compliance with the regulations therein shall be prima facie evidence of reasonable and proper precautions to prevent the escape of the fire. Offenses under this section should be taken up with the State authorities.

Subsection 6 is clear. It is an offense to leave a camp fire burning and unextinguished. Leaving a camp fire temporarily is not considered to be an offense within this subsection.

Forest Officer's Authority.

Any Forest officer of the United States has authority to arrest, without process, any person found by him in the act of violating the laws or regulations relating to the National Forests. (Act of Feb. 6, 1905, 33 Stat., 700, and act of Mar. 3, 1905, 33 Stat. L., 872.) This power to arrest without warrant should not be exercised except in cases of necessity and when the offender is actually caught in the act.

The arresting officer must take a person arrested without warrant before the nearest United States commissioner within whose jurisdiction the offense occurs, where he will be required to swear to a complaint and must obey the mandate of the commissioner, who will set the time for a preliminary examination of the accused. See sample complaint.

If a person is suspected of violating the Federal fire laws, but is not seen in the act, and his arrest and detention are necessary to prevent his escape, a warrant must first be obtained from the nearest United States commissioner.

Action in Case of Arrest.

The person arrested should be immediately taken before the United States commissioner who issued the warrant. The subsequent procedure will be the same as in the case of an arrest without warrant.

If in any case it is impossible to take the offender before a United States commissioner, he should be taken before a justice of the peace or other State officer mentioned in section 1014, United States Revised Statutes, which provides:

For any crime or offense against the United States the offender may, by any justice or judge of the United States, or by any commissioner of a circuit court to take bail, or by any chancellor, judge of a supreme or superior court, chief or first judge of common pleas, mayor of a city, justice of the peace or other magistrate of any State where he may be found, and agreeably to the usual mode of process against offenders in such State, and at the expense of the United States, be arrested and imprisoned, or bailed, as the case may be, for trial before such court of the United States as by law has cognizance of the offense. Copies of the process shall be returned as speedily as may be into the clerk's office of such court, together with the recognizances of the witnesses for their appearance to testify in the case. And where any offender or witness is committed in any district other than that where the offense is to be tried, it shall be the duty of the judge of the district where such offender or witness is imprisoned seasonably to issue, and of the marshal to execute, a warrant for his removal to the district where the trial is to be had.

In an arrest upon a warrant issued by a justice of the peace, the State forms may be used. There is no special form of procedure necessary, the usual modes of process against offenders in the States being available. A justice of the peace in one county may issue a warrant for an arrest in an adjoining county for offenses against the laws of the United States.

The officer seeking a warrant of arrest from any magistrate, State or Federal, must designate in the complaint the particular offense committed, and specify the statute and section violated. He should also be in possession of facts within his own knowledge, and not upon information and belief, which will convince the magistrate that there is sufficient cause for suspecting the guilt of the trespasser and issuing the warrant. A warrant ought not to be obtained until such facts are shown.

After an arrest is made it is not necessary to take the witnesses before the United States commissioner or State officer. The United States commissioner will set the date of hearing unless the prisoner waives preliminary hearing, and will subpœna all witnesses whose names are given to him. The State magistrate will imprison the offender or admit him to bail for appearance before the district court or grand jury. The witnesses will then be subpœnaed for appearance. A forest officer has no authority to arrest a person for the purpose of holding him as a witness or for the purpose of bringing him before a magistrate to testify or swear to a complaint. Witnesses are secured by means of a subpœna.

As soon as possible after the arrest a report of the case should be made to the district office.

The secretary's regulations have the force of law under the act of June 4, 1897, and violations of those regarding fire should be handled in the same manner as violations of the Federal fire laws with the exception of the wording of the complaint.

For offenses under the State law, forest officers have authority to arrest only after having been appointed deputy State fire wardens. (Sec. 9, chap. 264, laws 1905).

When possessing such appointments they may arrest without warrant for a violation of State fire laws committed in their presence. (Secs. 816, 817, 836, Cal. Penal Code.) When the offender is not caught in the act a warrant must be secured. The warrant must be obtained from and returned to a State magistrate—that is, justices of the peace, police magistrates in towns or cities, judges of the superior courts (county courts), and justices of the supreme court.

After the arrest the commissioner or magistrate will conduct a preliminary hearing at a time set by him. This is to ascertain whether there are sufficient facts to justify admitting the accused to bail or committing him to jail. Witnesses familiar with the facts should be subpœnaed for attendance at this hearing in order that it may be determined from their testimony which action may be taken.

In the preliminary examination and at the trial witnesses will, under the rules of evidence, be restricted in their testimony to facts within their own knowledge and will not be allowed to testify as to things which they have been told by others or have learned as common rumor. Forest officers should bear this in mind, since it will aid them in determining whether they have sufficient evidence to sustain their charges.

Evidence.

In all cases where no immediate arrest is necessary to prevent the trespasser's escaping, all the evidence and information obtained regarding the trespass should be transmitted to the district office, where the sufficiency of evidence will be passed upon and it will be determined under which law the case should be prosecuted.

The evidence necessary to support criminal action must be clear, definite, and positive. It should be remembered that guilt must be proved beyond a reasonable doubt, and therefore the evidence necessarily must be stronger than in civil cases, where only a preponderance of the testimony is necessary to make out the Government's case.

In all cases the name of the trespasser in full should be secured, his place of residence, his occupation, his whereabouts before the fire, what he was doing at the time of the fire, and names of the witnesses who either saw the act or have knowledge of the circumstances previous or subsequent thereto. This means all facts connecting the party with the fire.

It is necessary to trace the movements of the trespasser prior to the time of the fire and also to show his movements thereafter, because they will in most cases have a bearing upon his previous actions. These facts tend to rebut any alibi which the trespasser may attempt to prove. In fact, the good handling of cases necessitates securing of facts to overcome a possible alibi.

It may prove valuable at the time of the trial to have some information of the general reputation of the trespasser in the community where he lives or in the vicinity where he started the fire; and, in addition, whether he is responsible for other fires in that vicinity.

The language of Judge Whitson to the jury in the Fisher case, mentioned above, in this connection, is as follows:

> Evidence of other fires has been admitted here as far back as 1908. You are not trying the defendant for setting those fires and you should carefully distinguish between those and the issues which you have been called upon to try. Nor does the court express any opinion to you on whether those fires were set by the defendant. That is exclusively for your determination. This evidence was admitted solely for the purpose of showing with what intent the acts were committed; that is, were they purposely done? In other words, in the language of the indictment and the statute, were they willful?

In addition to the foregoing, the following facts must be secured: Time, place, and origin of the fire; area burned over; estimate of probable damage and basis therefor; status of land.

In each case a map should be submitted showing the status of the land, fire area, and location of various roads, trails, buildings, etc., in the vicinity in order to more clearly fix the region of the fire in the minds of those who examine the papers and for use at the time of trial.

Affidavits of witnesses familiar with the facts should always be obtained. If they refuse to give affidavits, statements showing the facts to which they can testify should be furnished.

Confessions.

In some cases the suspect may be found near the scene of the fire and admissions or confessions may be obtained from him *in the presence of witnesses.* In securing such confessions extreme care must be taken that the trespasser is not intimidated in any way or that he is not influenced by any promises of leniency. Such expressions as, "It will be better for you if you tell the truth," or any of like character should never be used. The suspected man may be accused of setting the fire, but at the same time it would be preferable to tell him that anything he may say may be used against him.

The reason for these precautions lies in the fact that confessions must be voluntary, and if they are not the court will refuse to allow them to be admitted as part of the evidence. The general rule is that confessions are voluntary when they are made by the person accused under such circumstances that his mind is entirely free from any influence either of fear or favor.

The northern district of California comprises Monterey, San Benito, Stanislaus, Tuolumne, Mono, and counties north thereof. United States commissioners within this district are as follows:

W. F. Anger, Covelo, Cal.
Herbert South Gans, Red Bluff, Cal.
Francis Krull, San Francisco, Cal.
Silas W. Mack, Monterey, Cal.
W. B. Maling, San Francisco, Cal.
George T. Rolley, Eureka, Cal.
Richard Webb, Jackson, Cal.
Joshua B. Webster, Stockton, Cal.
E. M. Whitney, Willits, Cal.
Harry M. Wright, San Francisco, Cal.

The southern district comprises all counties other than those in the northern district. United States commissioners in this district are as follows:

Garth B. Campbell, Fresno, Cal.
H. T. Christian, San Diego, Cal.
W. E. Simpson, Bakersfield, Cal.
H. I. Tupman, Bakersfield, Cal.
C. N. Williams, Los Angeles, Cal.

SAMPLE COMPLAINT.

UNITED STATES OF AMERICA,
NORTHERN DISTRICT OF CALIFORNIA,
City and County of San Francisco:

Before me, H. M. Wright, a United States commissioner for the northern district of California, at San Francisco, personally appeared this day John Doe, who, being first duly sworn, deposes and says: That in the State and northern district of California, on or about the 8th day of July, 1911, RICHARD ROE, in violation of section 52 of the Criminal Code of the United States, and within the jurisdiction of this honorable court, did then and there willfully, unlawfully, and knowingly set on fire and cause to be set on fire timber, underbrush, and grass upon the public domain of the United States of America within the limits of the Plumas National Forest, whereby he did burn and destroy large quantities of timber, underbrush, and grass covering large portions of the Plumas National Forest.

Against the peace and dignity of the United States of America and contrary to the form of the statute of the said United States of America in such case made and provided.

Subscribed and sworn to before me this —— day of ———.

——— ———.

Commissioner aforesaid.

PART II—DIRECT CONTROL.

CHAPTER IX.

ORGANIZATION OF CONTROL FORCES.

Qualifications of Men.

The men who make up the protection forces on the National Forests are successfully placed and organized when, by reason of their efforts, the area burned over by the end of a season is at or below the accepted standard. To reach this standard, these men must have been the means of preventing many fires from starting; they must have seen each fire that did start, immediately it became visible, and accurately determined and reported its location; and they must have had at hand the transportation and equipment, and have proceeded immediately by the quickest route to each fire and constructed an impassable barrier around it.

Each one of these operations calls for high-grade qualities in the men composing the control force—constant watchfulness, quick and accurate thinking, speed in travel, and gruelling physical labor on the line.

The success of protection work depends, first, last, and all the time on the men who compose the rank and file of the control force. No matter how scientifically correct each piece of equipment may be, no matter how mechanically perfect the communication system may be, no matter if protection plans are drawn to forecast and provide for every possible contingency—the machine is effective only when the men who compose it are of the right caliber.

The supervisors who have developed the best protective systems are the ones who have been able to instill into their men a strong spirit of competition—not only with with each other, but with each fire. On the Forests where jumping onto a fire in the greatest possible hurry is considered an absorbing game, where every man is up on his toes all summer long—there the best protection records are made. The older men in the Service must make the new men understand that protection work is not a job they have hired out for, but a game they have agreed to play, and slovenly work on the part of any one man will make the whole Forest organization the loser. The very nature of the protection game indicates certain qualities that must be present in the men who will play it well. By questions and a few simple tests, the employing officer, whether he is a supervisor or district ranger, should satisfy himself that the applicant possesses the natural mental qualifications of a good fire fighter. One is the ability to think quickly, to size up immediately a number of possible courses of action, and instinctively select the right one without consciously going through a logical train of reasoned thought. The applicant might be asked, for instance, what he would do with a fire fighter who broke his leg when on the fire line. Without seeming to apply a test, the time taken and the judgment shown in answering may be mentally noted. Self-reliance is an essential qualification, and its possessor usually has the corollary—ability to take care of himself and others in critical situations. Whether the applicant has it or not is indicated in his general bearing and can be further brought out by questions as to his personal experiences.

Besides the necessary inherent mental qualities, the applicant should have certain further training that may have been gained by previous experience. He should have the ability to learn a country quickly and well enough to find his way about without

roads or trails. He should know horses with that sympathetic understanding that realizes their needs and how to get the limit of work out of them and at the same time keep them in condition—that regards them as personalities rather than machines. He should be thoroughly familiar with the handling of tools used in protection work, and the more experience he has had in the handling of men the better. A fair measure of a man's stock of these qualifications can be gained by questions and simple tests.

That a man must be physically sound for this work we know, but a standard of soundness has never been defined. For protection purposes a man should be ordinarily muscular, with no tendency to pulmonary or heart weaknesses, and should be entirely free from any chronic disease which is liable to incapacitate him during his period of service. These facts can be determined by questions, by observation, or, if necessary, by medical examination.

There is no intention to institute a guard examination or require an applicant to measure up to any given figure on a scale of rating. But it is urgent that a simple and effective method be used by all employing officers to insure the rejection of the clearly unfit.

A reasonably liberal standard rate of pay has been adopted for short-term men, *with provision for fixed increases* for recurring service. The purpose of this is to put a premium on good men returning to the Service for protection work, summer after summer—to build up a dependable protection militia through publicly announced cash bonuses. It is a plan which looks to the future and deliberately contemplates spending more money per man per year in order to get more protection per man and to get the men at the time and for the periods they are most needed.

The following rates of compensation will be standard for District 5:

(*a*) For self-subsisted patrolmen or forest firemen furnishing their own horses—$75 per month the first season, $80 per month the second season, $85 per month the third season, and $91.66 per month the fourth and succeeding seasons; all horse feed to be furnished by the Service in every case.

(*b*) For Service-subsisted lookouts, no mounts needed—$60 per month the first season, $65 per month the second season, $70 per month the third season, and $75 per month the fourth and succeeding seasons.

(*c*) For short-term assistant rangers in immediate charge of the protection work of a district under the general supervision of the district ranger—$100 per month.

Subsistence for forest patrolmen and firemen will be figured at $16 per month; for lookouts at $19 per month.

When patrolman or fireman service can be performed more efficiently on foot or where Service-owned mounts are furnished, $15 less per month than the rate in schedule *a* will be paid.

Motor cycle patrolmen will be paid $33.33 per month, in addition to the rate specified in schedule *a*, for the use, operation, and upkeep of their machines.

Horse feed, in every possible case, will be purchased in bulk in advance and distributed; the quantity allowances under varying conditions to be worked out by each supervisor on the basis of the proper ration per necessary horse per day. When sufficient data are available, these rations will be standardized.

Short-term men who by reason of the character of their services do not qualify for advancement from the $80 to the $85 grade at the end of their second season's work will not be reemployed.

Supervisors are authorized to employ men at other than the standard rates when, in their judgment, it is clearly good business to do so. When such a departure is contemplated, the district forester should be informed briefly of the circumstances.

An example of when a departure from these compensation standards is clearly good business might be found in certain sections of southern California where a long fire season offers an average of service of six months and the proximity to very large labor supply renders it entirely unnecessary to make any special inducements to get the right kind of men, year after year, for the period they are needed.

This standard of protection salaries will begin to go into effect the first of the 1914 fire season. Except for horse feed allowances, no general advances will be made this year. All new men will be started at the entrance scale of pay, but public announcement will be made of the contemplated advances for those who prove fit and return next season. Men who have had previous service and return this season will do so at the entrance rate, if no other agreement had been made with them by the supervisor. Men already receiving or promised a higher compensation than the entrance rate will wait for further advances until the schedule catches up with them.

The ideal is, of course, to have on duty the maximum number of men during the period of the greatest fire danger. This is obviously the only way in which the greatest protection value can be secured from the expenditure of a given sum of money in the California forests and climate. Since the ideal is to reach and hold each fire within a 10 or a 100 acre standard, it would seem at first glance that the seasonal increase in the number of fires should govern absolutely the seasonal increase in the number of the control forces. This would be true only if the rate of spread of all fires was the same in all localities and at all periods of the summer season. That the number-of-fires curve does not necessarily parallel through the season the curve of number of acres burned is shown by the following figures derived from three-year averages (1911–1913):

	Frequency peak: 20-day period in which most fires occur.	Acreage peak: period of highest total acreage burned over.
Lassen	July 11 to 31	Aug. 21 to Sept. 30.
Santa Barbara	July 21 to Aug. 10	July 11 to Oct. 20.
Stanislaus	Aug. 21 to Sept. 10	July 11 to Aug. 31.

The reasons why these curves do not parallel are three: Many July fires occur from lightning, and usually in areas where, on account of altitude, the spread is slow; fires later in the summer (August) are more apt to be caused by campers at low (dry) elevations and in highly inflammable cover; and as the drought period lengthens and the whole country becomes increasingly dry there is a consistent increase in rate of spread.

Neither one of these curves can be followed to the exclusion of the other in pyramiding summer forces. Both must be platted on the same sheet from the best data available, studied carefully, and the curve of protection force worked out by the application of the supervisor's best judgment in reference to both of them. Here is an example (fig. 1):

From this diagram it will be seen that, for a normal fire season, the period within which the greatest speed in control is needed is between August 1 and September 30—two months—and that this period coincides exactly with neither the frequency peak nor the acreage peak. Concentrating the forces as shown in the diagram would mean 30 men on duty during the danger peak, while, at the same average rate per man-month, only 19 men could be employed if each was retained five months.

Protection, Militia.

The high-grade men needed and the short-time job we have to offer point clearly to the need of building up a protection militia that can be drawn upon summer after summer from substantially the same men. By protection militia is meant an auxiliary force resident in the region, having other interests and employment during the season of no fire danger, who can be counted upon to accept guards' appointments each summer during the slack period of their own work. Young men developing homesteads in the mountains, placer miners in regions where water is not available in summer, country-bred university students familiar with some particular mountain locality—these illustrate the type which must make up the protection militia.

The quality of the man is shown most clearly during service. As each particularly good one develops, every effort must be made to insure his reemployment the next summer. Special trips by the supervisor in order to meet the man personally and use his influence and show his appreciation of good work may result in availability next season, even after the district ranger has failed to secure his promise to return. Immediately after the rains in the fall is the time to set about organizing the next summer's protection force. Each supervisor should gain an accurate measure of the individuals in his past summer's force by a personnel report on each from the ranger best quali-

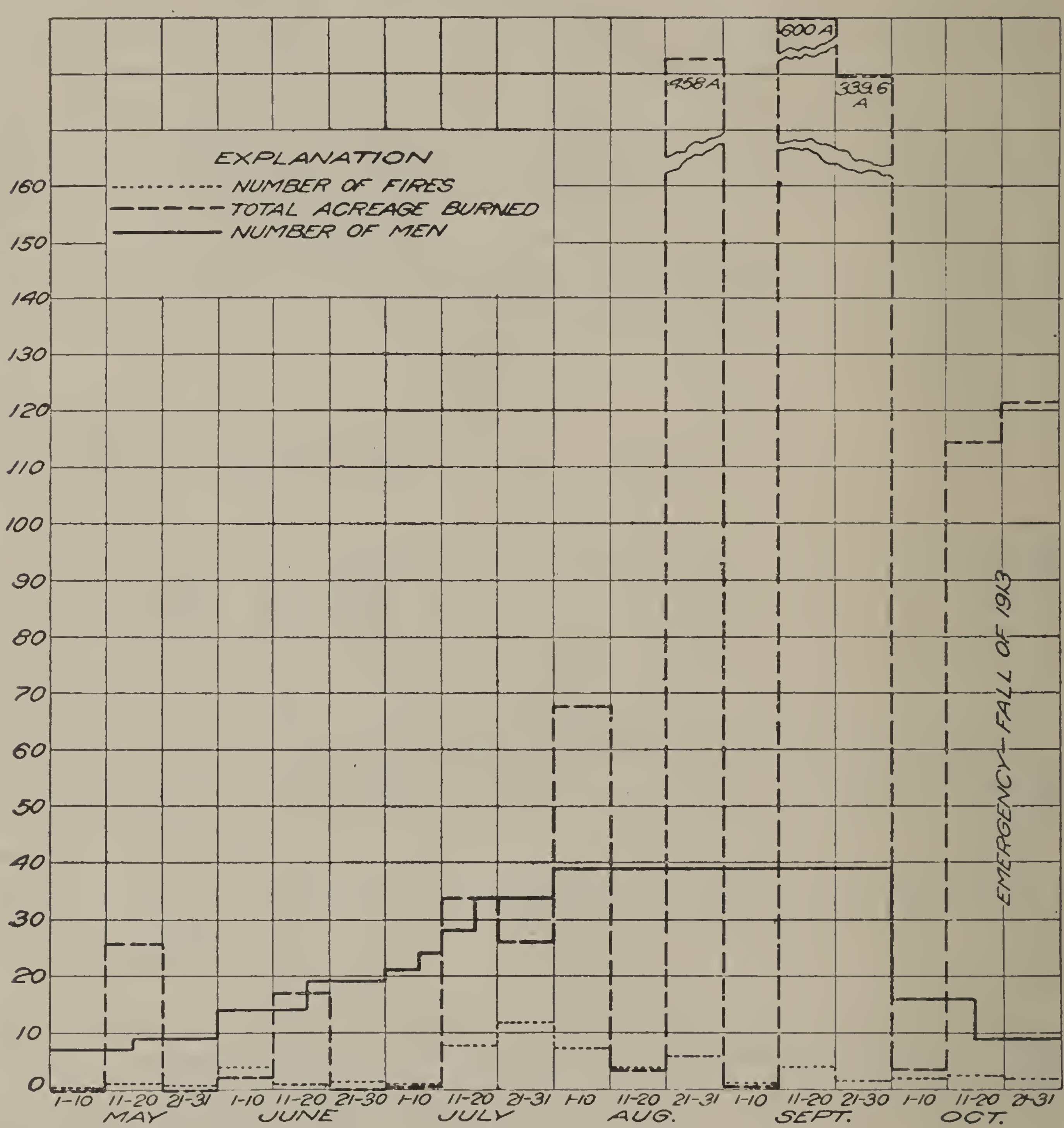

FIG. 1.—Lassen National Forest. Average 10-day fire record 1911 to 1913, inclusive.

fied to pass judgment on his work. The following form is suggested, which may be mimeographed for local use:

GUARD PERSONNEL REPORT.

.... Name.	.... Age.	.... Married or single.	.... Family.
.... Period employed.	.... Duties.		.... Salary.
.... Home address.	.... Home occupation.	.... Address on duty.	

Information.	Rate on basis of 100.	Remarks.
General health		
Physical endurance		
Habits:		
On duty		
Off duty		
Personality		
Care of horse		
Care of Government property		
Knowledge of country		
Ability to enlist and handle men		
Promptness in getting to fires		
Ability in handling fires		
Ability to provide for a fire crew		
Care of men		
Protection record last season		
Reliability		
Enthusiasm and loyalty		

Does he own a horse? .... Should he be employed next season? .... Will he accept appointment? .... If not, why? ....

Further remarks:

....
Forest Ranger.

On the basis of these reports, the best men may be followed up. If they decline reemployment, the reason may be ascertained and removed if possible.

A protection labor agency will be maintained in the district office, and information upon his qualifications collected on every applicant for summer work. Supervisors unable to obtain all their short-term men locally may state their needs, and the papers of those apparently most fit for duty on their Forests will be submitted to them for further direct correspondence with the applicant.

Functions of the Control Force.

Every member of the fire-control force on a Forest has one primary function to fulfill. He may or may not have other secondary functions. Taken as a whole, the control organization must supervise protection work, must prevent fires from starting, must detect every fire that starts, and must corral or control each one that starts. The functions, then, are supervision, prevention, detection, and control.

Let us take up each function separately and determine to which unit of the organization it properly belongs as a primary function, how that unit can best be placed to fulfill it, and to what extent other units can assist in its fulfillment.

Supervision.

Supervision of the protection work on a Forest is the responsibility of the supervisor. He may delegate a portion of it; he may authorize his deputy or other officer of the Service as inspector of the machine, but the district forester and the Forester are going to hold him accountable for the season's record. Similarly, the responsibility for the protection of each ranger district is the district ranger's; he is the man the supervisor is holding accountable for the protection of that district. The same officers must exercise general direction also over the administrative work in the areas for which they are responsible; but, if the actual performance of it detracts materially from their value as supervisors of both classes of work, they must leave such performance to administrative assistants. Divorce of protection and administrative work has been demonstrated by experience as essential to the success of the former, but this divorce must stop with the performance. It must be combined in the supervision, in order that both may profit by the intelligence best qualified to direct each.

To illustrate: The fire situation may be so acute in a district that the district ranger finds it necessary to stay at the headquarters' phone receiving reports from lookouts,

deciding what guard should go to each fire, giving him his instructions, calling out volunteers, and arranging with storekeepers for forwarding supplies. He may see the assistant ranger, who is doing the administrative work of the district, only once a week when he talks over cases with him, decides upon recommendations to make, and plans next week's administrative work.

In another case, advance plans may be so perfected that the lookout is reporting fires direct to firemen and patrolmen. Only in the exceptional fire is it necessary to forward volunteer men and supplies. The district ranger spends his time in field inspection of the protection machine, planning improvements, keying-up the force, talking to the traveling public, and doing some administrative work. When it is necessary, he details an assistant ranger to the headquarters' telephone. In both cases he is in charge of both the protection and the administrative work on his district.

This is directly opposed to the "Forest Fire Chief" theory of organization which proposes to carry the divorce of the two lines of work on to the supervision of each, and put a man other than the district ranger in each ranger district to take entire charge of the protection work and report directly to the supervisor. This theory has been carefully considered and rejected; and the former—the supervisor and the district ranger as the responsible directing heads of both administrative and protection work on the Forest and on the ranger district—will be the standard organization of District 5.

Prevention.

By prevention is meant active work which has for its purpose a reduction in the number of fires started from human agencies. The method of carrying out this function of the control organization will, of course, be designed to meet the form which the fire-causing agencies take. Upon that form depends whether this particular function can best be fulfilled by one unit of the force who is depended upon to fill no other, or whether a unit performing some other service primarily can satisfactorily perform the function of prevention incidentally with his other duties.

Patrolmen.

To illustrate: The Sequoia National Park is the destination of many hundreds of summer campers, and one popular route to it is the Summit Trail through the Sequoia National Forest. This route entails a three or four day trip with pack-horses from the San Joaquin Valley, which means that every party will build three or four campfires on the way. To see that the man in every party responsible for building and extinguishing these fires has a proper sense of the urgency of care with them, and to see that every fire built is really out when left, is a service requiring the entire time of one man. The Forest officer detailed to perform it, because of his essential mobility, can be depended upon for no other protection service except such reserve fire-control work as can be got out of him with the imperfect communication between him and the rest of the organization that his mobility necessarily entails. He is the true forest patrolman; his primary function is to prevent fires starting, and the full performance f that function is possible only when he is on the move; also the full performance of that function renders the full performance of any other function impossible.

Forest Fireman.

The opposite extreme may be found where practically the entire risk factor of a control division is concentrated in the residents of a small mountain settlement, which town is also the logical base for the Forest officer depended upon for fire control in the division. Here the fires are caused by men from the town who go out into the surrounding country in the course of their occupations during the day, returning to town at night. The Forest officer stationed at the telephone in town can exercise the function of prevention fully as well, if not better, from his fixed station as if he were moving about. In such a case he would be a forest fireman, whose primary function was

fire control, but who was in position to perform as a secondary function the prevention service for that locality.

Detection.

Fire detection is so clearly a function of one unit of the organization—the lookout service—that it is necessary to devote a chapter to it. A certain amount of detection is, however, performed incidentally by forest patrolmen and forest firemen; by the former whenever he discovers an unextinguished camp fire, and by the latter when from his fixed station he sees and starts for a smoke without first being notified of it by a regular or volunteer detection agency. The latter class of officers have been erroneously called "secondary lookouts." While it is true they may render some detection service incidental to their primary function as fire controllers, still they should be designated on the basis of the function they are primarily employed to perform.

Control.

This brings up the function of fire control. If men have been successfully placed to move with and to cover the moving risk, if it is reasonably sure that the lookout service will detect each fire that starts, it remains to place the rest of the available men in such positions as will enable them to receive word of each fire and get to it in the shortest possible time. The man who is standing still in the exact center of a circle can get to *any point* in the circumference of it the quickest *more times* after the word "Go!" than the man who is wandering about somewhere within the circle. Furthermore, he will hear the word "Go!" quicker.

This is exactly the theory of the "stationary patrol"—a makeshift title which is a contradiction in terms. This man will hereafter be called the forest fireman. The argument most often raised against this form of organization is the effect on the public mind of a Forest officer apparently sitting still and doing nothing. If the man looks the part of a forest fireman, if his horse is saddled and tied to a rack outside his station, if his fire-fighting tools and equipment are in readiness and in evidence, and above all, if the station is furnished with a neatly lettered sign, "Eldorado National Forest—Fire Control Station No. 10," the public will soon be as completely educated to this sight as they are to firemen "loafing" about fire-engine houses in a city.

The control station may be considered 100 per cent effective whenever the forest fireman is within hearing of his telephone bell. To provide a way to give both the man and the horse the exercise necessary to keep them in condition will require considerable study on the part of the supervisor. Extension or intensifying devices on the telephone bell may be secured which will give the forest fireman a radius of leeway covering a quarter of a mile or more from his station, within which area he may perform considerable useful work.

The forest fireman's function is to get to each fire and control it. Considering the possible expenditures that a delay will entail, it is considered that travel time (see p. 16) is worth not less than $5 a minute. Speed in this time period is the essence of successful protection. If the control division is so rough that foot travel is quicker than riding, the forest fireman should walk to fires. When riding is the quickest method of travel, the fastest practical gait must be maintained.

Importance of Travel Time.

It may seem presumptuous to tell forest rangers how to ride; but many of them have not stopped to think what their riding speed means when translated into minutes saved in travel time. The typical mountain riding gait in California is a walk which averages about 3½ miles an hour. This may be all right for long trips on administrative work, but the habit of riding at a walk should not prevail in traveling to fires. The man is prepared to make extraordinary physical effort when he arrives at the fire, and rest afterwards. The horse, who is a part of the protection organization, should be required to do as much. Suppose the distance from the control station to

the fire to be 7 miles, here is what the horse's gait means, translated into minutes saved:

Gait.	Miles per hour.	Travel time.	Minutes saved.
		H. M.	
Flat-footed walk	3½	2 00	....
Running walk or slow trot	4	1 45	15
Brisk trot	4½	1 33	27
Brisk trot and lope	5	1 24	36
Lope	5½	1 17	43
Fast lope	6	1 10	50

To get at least one man to each fire as soon as possible is the primary object of the organization. The forest fireman should not stop to assemble men and arrange for their supplies, equipment, and transportation—he must *go*, just as a fire company in a city goes on an alarm. Arrangements for reenforcing him on the fire line may be made immediately by the district ranger, an assistant ranger, the lookout, or, best of all, by a volunteer per diem guard hired for this purpose and residing where he will be available quickest. Often, by heliograph or otherwise, the forest fireman can inform the lookout from the fire whether he can handle it alone or not.

Detection by Forest Firemen.

The time center of a control division, which is theoretically the exact place at which the control station should be placed, may have to be modified (temporarily, at least) by the present state of the communication system. It may also have to be modified to secure intensification of the detection system. Even on Forests well supplied with permanent lookout stations there are sure to be many scattered areas (some small and some not so small) on every control division into which the lookout can not see. Whenever a topographic point from which country invisible to the lookout can be seen is situated reasonably near the time center of the control division it should be occupied by a control station and its forest fireman. Communication facilities should, obviously, be furnished to it.

Standard Forest Time.

The importance of time studies has been emphasized all through this manual. The latest forms used in protection work call for a statement of the day, hour, and minute at which every operation occurs. To secure reasonably accurate elapsed-time figures the supervisor should make arrangements for synchronizing timepieces throughout the Forest organization. Standard Forest time should be given out from the supervisor's office twice a week and through the telephone system reach all officers. The watch carried by the average ranger will not vary within this period to a degree which will render time figures unusable.

Even though the traveling public comes eventually to be as careful with fire in the woods as they are in the house, and the number of fires decreases enormously, the vast areas of National Forests will always be guarded from fire by some such organization of men as has been described. In a very few years 10 acres will represent a protection standard that is too low. The people will demand that no fire be allowed to cover over 2 acres, and they will be willing to pay for that degree of protection. Fire fighting with large crews of men, such as we are all familiar with now, will be a most unusual occurrence, and any fire over 10 acres in size will be the subject of a most searching investigation to fix responsibility. The trend of the times is toward regular recurring summer organization on each Forest that will take care of every fire at the start and call on no help outside the Service.

Ideal Organization.

The time is not far distant when each inflammable forty of each Forest will be under the eye of a properly equipped lookout, each travel route will be covered by its forest

patrolman, and each control division will have its properly located control station manned by its forest fireman. Each station will be in telephone communication with the lookout covering the division. On the wall of each will be a large-scale map cut by horizontal and vertical lines into 40-acre squares. Each square will be designated by letter and number. By previous study there will have been worked out for each square the shortest route to it from the station, the rate of spread of fires in it with each mile of wind velocity, the direction and velocity of the wind for a given direction and velocity at the lookout station, and the one best tool for cutting the particular cover in it, other specialized tools being cached where needed.

Then, when the forest fireman's telephone rings and he hears the lookout say, "Just smoking up in A 16; wind here 310 degrees; seven and a half an hour," by reference to his map he knows he has a bear-clover proposition in A 16, and a 6-mile wind blowing from the east. He knows his fire is spreading westerly at the average rate of 4 feet every 10 minutes. He knows the quickest way there is down Double Bunk Ridge on horseback, and that he wants a sharp plantation hoe and a boy's axe.

Control Divisions.

With a protection force which increases in numerical strength as the fire season advances, the protection plan must necessarily divide the Forest into the highest number of control divisions that will be needed, and must determine in advance the time center or proper station location for each one, for each pair, for each three, or for each four.

Suppose the number of forest firemen on June 15 is 6, and the number on August 15 is 24. Then each man on June 15 must cover four divisions, and possibly the logical station point for the four is not the same as the station point for any one of the four. With 12 men on forest fireman duty, each is covering two divisions, and it is not until August 1 that each division headquarters is manned. The time center is the point from which every fire that on the basis of past history and present risk factors will occur within the division can be reached in the shortest time. A division's size will be determined, first, by the number of fires that will occur, and, second, by the rate of speed at which travel to them is possible. This second factor, being influenced by topography, will largely fix the shape of the division. All this points toward portable shelters for the forest firemen, to which provisions and horse feed must be delivered at intervals during the season.

Emergency Control Forces.

The organization of emergency control forces should be covered by the forest protection plan. The supervisor who is skilled in recognizing an emergency does not wait for disastrous fires before acting. One of the first things he must secure is an increase in his control force corresponding to the seriousness of the emergency. The extra force needed in time of dense smoke or other emergency conditions can not be employed all summer. The cost would be prohibitive, and besides the extra force is needed only at these emergency periods. A flexible organization permitting immediate and full adjustment of the control force to the fire danger is the ideal to be sought.

It has been demonstrated that emergency needs for men and horses for control work can be met without serious difficulty. By using personal influence, appealing to public spirit, or offering larger pay, patrolmen and firemen can be secured for the few days or weeks of the emergency. Many men who could not be secured for ordinary guard duty are public-spirited enough to serve as needed to meet an emergency.

The following will be standard practice in District 5:

Definite emergency control plans will be prepared, covering—

1. The total extra control force needed to meet emergency conditions.
2. Definite advance arrangements with each man covering rate of pay, duties he will agree to perform, how long he will work in case of prolonged emergency, and advance instructions when such can be given.

3. Written plans covering as definitely as possible the mobilization, stations, supplies, communication, and duties of varying numbers of men whose services would be required.

Protective organizations have gone down in utter defeat when thorough organization of this kind would have saved the day.

With the preliminary work well done the rest is easy and as effective as any human action can be when confronted by an emergency fire situation. When the emergency is recognized, the number of men to be added and the total emergency cost on a per diem basis should be determined and wired the district forester. As soon as authority is received from him a few instructions should start things and start them before disastrous fires are burning.

Organization of Volunteer Forces.

When a fire starts, the previous organization should be such that no single potential fire-fighter fails to do his best toward the suppression of the fire in the fewest possible minutes. The more perfect the advance organization the more nearly automatic will be the action of the suppression resources.

Low cost of suppression is a secondary but important qualification to be sought in developing suppression forces.

The whole field of possible fire fighters may be divided into three classes. They are, all Forest employees on the regular pay roll; residents or or near the Forests; and the indefinite, unorganized forces to be drawn from communities more distant from the Forests.

The special advantages of the regular paid force are, first, it is under the continuous and exclusive control of the Forest Service; second, it is always on duty—there need be no break because a man unexpectedly chooses to go on a visit or make a business trip; third, since the force is paid for all its time and is entirely under the control of the Forest Service, the maximum of readiness to go can be required—the get-away of the ranger or guard should take the fewest possible number of minutes or seconds to which it is possible to reduce the time elapsing between receipt of the message from the lookout and the start for the fire; and, fourth, with effective organization and right salaries, this force should consist of seasoned and highly trained men. The disadvantage of this force is that it costs from $200 to $800 per season per man.

The advantages of residents as fire-fighters are:

1. They constitute a fire-fighting resource of enormous power, already on the ground without expense to the Forest Service.
2. As a rule, residents are skilled mountaineers. In fire-fighting experience and value they approach the regular paid force.
3. Not only is this class on the ground without expense to the Forest Service, but the cost of its actual use is comparatively low.

The disadvantages of residents as fire fighters are:

1. The get-away speed is not as great as with the regular members of the control force. There are instances of as great speed from volunteer as from regular forces, but this equality of speed is undoubtedly due to a failure to develop the speed of the regulars to the maximum. It is seldom possible to arrange to have a volunteer keep his horse and outfit ready for instant use.
2. No single individual can always be depended upon. Until ordered to a fire, his time is his own, and he can not be expected to dispense with private business and pleasure trips.

Cooperation.

Cooperation in fire protection is nothing new. In theory, at least, it has always been of importance, but it has usually been an indefinite factor of little real force in practice. It has remained for certain field officers in District 5 to take the lead and demonstrate what can be done by aggressively going after and organizing volunteer forces. The results are sometimes spectacular. Interest and extreme effectiveness are regularly secured from men who would be expected to be indifferent. When mechanics and business men not dependent on a Forest and living 20 miles from

a boundary can be induced to enter a volunteer company and drop their regular work at a word from the Forest officer, the method *is* practical and too important to overlook. If such organization and snappy action can be secured on one Forest, it can be secured on others. Volunteer forces should be developed to the limit. It costs next to nothing to organize them, and they will supplement the efforts of any regular force. The certain effect on public sentiment, alone, justifies the effort to organize.

The following practice will be standard in District 5: The utmost development of volunteer forces will be expected. Volunteer forces are defined to include all trustworthy individuals or groups residing permanently or temporarily on or near a National Forest and not on the regular pay roll.

There are only two rules for developing this resource: Go after it, and organize it. The appeal must be adapted to suit each individual or group. Probably the personal influence of the Forest officer is the most useful tool. A peculiar fact is that once a man has been enlisted and called into action a time or two he becomes interested in the work for its own sake and is thereafter a dependable unit in the protective force.

The great variety of conditions make it impracticable to prescribe methods to fit each. Whether individuals will be united in companies, whether employees or employers shall be dealt with, what signals can be used, whether volunteers shall be appointed per-diem guards or fire wardens or given no appointment, can all best be left to the officer on the ground.

Plan of Organization.

There is, however, one unvarying principle to be observed. Advance arrangements should be as complete as it is possible to make them, and when possible companies should be formed with regular officers, each of whom has definite duties and responsibilities. Such organization, it has been proved, has an attraction of its own. The following is a sample set of instructions to certain members of an actual company:

Captain.

It will be the captain's duty on hearing of a fire, seeing a fire, or if for good reasons he thinks there is a fire in his territory, to investigate, by using the telephone or by other means when necessary, the location, size, and general conditions at the fire. If he thinks he can handle the fire with his men, he should notify them at once, with necessary instructions. Before going to the fire, he should notify the district ranger or Forest supervisor of the action he is taking. He should decide on the best and quickest means of getting to the fire, and notify his packer what he needs—as the number of horses, pack horses, teams, and wagons or automobiles—and where he needs them. He should notify his quartermaster of the number of men he will take, and how long he expects to stay, and whether he will need supplies or not.

The captain will be furnished time slips on which to keep the men's time. On this card he should state the hours worked, thus:

Richard Roe, June 20, 8 a. m to 6 p. m., 10 hours, 40 cents per hour, $4.

The captain and his crew will be subject to call for help by chiefs of other companies or Forest officers on any part of the Forest. In this case, the captain will always be given instructions where and how to go.

If he needs help from other companies, he should call the district ranger or supervisor, if possible, and inform them what he needs. If he can't get an immediate communication with either, he should not hesitate to call on the chiefs of the other companies he needs and give them instructions how and where to come. Notify the chiefs called on whether they should provide their own supplies and equipment, or whether he can provide their own supplies for them. When this action is taken, always send a message to the Forest officer as soon as possible.

On reaching a fire, the captain should first look the situation over and lay plans and instruct his men what he is going to do, and see that all work is done with the same aim in view.

In case it is to the best interests of the fire crew to dispense with the services of some outside help and they demand their wages, the ranger will make arrangements to pay them at once. If possible, they should be persuaded to wait for the pay until it can be paid by check from San Francisco. The captain should immediately report to the ranger any wilfull negligence or disability on the part of any member of his crew.

He should report any needed improvement in equipment and supplies. In all cases he should use his judgment as to what should be done, and do it with the least possible loss of time.

He should initial all bills given him by the quartermaster or packer for supplies, sign all time cards and forward them with any other expenses incurred to the ranger. These bills will be certified and forwarded to the district forester at San Francisco, and payment will be made from there by check. This usually takes from one to two weeks' time.

In case the captain is absent when a fire is reported, the first man on the list of firemen will take charge as captain until his return.

The captain will be paid 50 cents per hour actual time. This includes time spent in getting ready to go, time spent keeping his accounts, or any time actually worked, including time going and coming.

Quartermaster.

It shall be the duty of the quartermaster to get provisions and cooking utensils ready and in shape to transport, and either hire a cook or take charge of this work himself. He should see that plenty of good substantial food is taken, and see that a meal is always ready for a man that comes in from the fire line hungry, either night or day.

He should keep a list of cooking utensils taken and check up on arrival at camp, on breaking camp, and on arrival at headquarters; thus preventing loss as much as possible.

He should always get an itemized bill of everything he buys, and check up at camp to see that everything is there. He should insist on the packer or anyone who orders goods for him getting an itemized bill so that the goods can be checked. He should O. K. all bills, and turn them over to the chief on arriving home. The bills should be fully itemized as follows: 5 pounds beans at 6 cents, 30 cents—and not 5 pounds beans 30 cents. Care should be taken, as failure to do this delays payment of the bill. Standard bills of supplies will either be furnished and kept at some handy place, or, where stores are handy, bills will be filed so they can be ordered by number. The quartermaster will be furnished a copy of these bills and the places to get them. He may find it advantageous to get subsistence for the crew at some established place, such as a hotel, or private dwelling, or cattle camp, and should do so when he considers it best.

He will usually be able to stay at a fire camp and order any provisions needed through the packer, but in serious fires might have to stay at the supply depot; in this case he will be relieved, if possible, by a Forest officer.

He should not hesitate to buy any provisions or cooking utensils needed, and may get them from the handiest place.

When ordering through other parties he should if possible write and sign his order. He should have all bills charged to the Forest Service, ... National Forest.

When a camp is necessary he should locate at as handy a place to the fire as possible and at the same time be reasonably safe, and fix it up so the men will be as comfortable as possible while in camp. He will be able to add much comfort to the men by care in locating camps and arranging them, and such comforts will be highly appreciated.

He will be paid 45 cents per hour actual time worked, including time going and coming.

In small fires, where the foregoing duties are not necessary, he must place himself at the disposal of his chief.

Packer.

It will be the packer's duty, when notified of a fire, to get the necessary means of conveyance—such as automobiles, teams, and wagons, or saddle and pack animals—for the conveyance of men and supplies, and to transport the supplies and take care of the stock by providing feed and water.

He will be held responsible for all transportation. A list will be prepared, showing where he can get saddle horses, pack horses, automobiles, and teams and wagons, and the number he can obtain.

He should always get the quickest transportation possible. In a great many cases the members of the companies have means of transportation, which, in that case, should be taken.

He should keep an itemized statement of expenses, as:

John Jones.

1913.		
June 6.	1 saddle horse 1 day at $1.50 per day	$1. 50
6.	1 automobile 1 day at $5.00 per day	5. 00
	Total	6. 50

O. K.: JPB, packer.

All equipment, supplies, or transportation obtained from the same firm or individual may be covered in one bill. In this case the chief, quartermaster, or packer should O. K. the bill. When he has obtained all the bills he should give them to the chief, who will forward them to the ranger. The ranger will then make out a voucher covering the articles and forward it to the person who furnished the articles for his signature. As soon as it is returned to him it is sent to the supervisor, who forwards it to the district forester at San Francisco for payment, which is made by check from there direct to the person who furnished the articles.

In small fires, where the above duties do not keep him busy, he must place himself at the disposal of his captain.

Foreman.

It shall be the foreman's duty to respond promptly when called upon by the captain or Forest officer, and assist in getting ready to go to the fire and to get there as quickly as possible. He should be prepared to take anyone's place who may be absent. He should familiarize himself with the duties of the others, so that he can be able to step into their places if called upon to do so.

In case of large fires, where many men are used, he will probably be placed in charge of a crew, and in such case his wages will be increased 5 cents per hour while so engaged.

He should work with perseverence to better the plan his chief has made, regardless of discouraging circumstances; that is, even though the fire is apparently getting the best of it.

He will be paid 35 cents per hour actual time worked, including time going and returning.

Transportation.

Each member will be allowed transportation to and from fires, and any bills in this line will be promptly paid. In case a member uses his own means of transportation he is entitled to pay for it. Saddle horses and pack horses belonging to members will be paid for at the usual local rates.

Tools and Supplies.

All tools will be furnished by the Forest Service. If you can get to a fire quicker by taking your own tools you may do so, and if they are damaged you will be reimbursed.

In case any tools are broken beyond repair on the fire line, they may be abandoned, but you should notify the quartermaster or a Forest officer so he can account for the tools.

No member should buy and pay for tools from his personal funds. If tools are needed, they will be bought by the ranger or quartermaster. All subsistence will be paid for by the Service. If you get meals or lodging at hotels or private houses or camps, ask the proprietor for a bill and O. K. it and forward it the same as other bills.

CHAPTER X.

FIRE DETECTION.

Elapsed Time Periods.

The object of a study of the direct-control system has been defined (page 14) as that of so placing the protection money, men, and facilities on a Forest that the minimum time shall elapse between the start of a fire and the start of the fight. For the purposes of this study this time divides naturally into three periods for every fire, and the area burned over will vary directly with the number of minutes in each:

1. Discovery time—or from the minute the fire starts to the minute it is discovered;
2. Report time—or from the minute it is discovered to the minute of receipt of report of it by a man equipped to start to fight it;
3. Travel time—or from the minute of receipt of report to the minute the first stroke of work is done on the fire line.

The length of the first and second periods depends on whether there are men to see each fire the minute its smoke is visible and whether these men have the means to determine and communicate its location to the man who is in position to reach and fight it. The detection system, then, may be defined as the men and facilities depended upon to discover, locate, and report fires; and its object is to do so accurately in the shortest possible time.

The essential features of a system that will accomplish this object best are (1) that the entire area dependent upon it for discovery is visible, (2) that it renders continuous service, and (3) that it reports to the right man in the shortest possible time the accurate location of every fire that starts.

Volunteer Detection.

Two entirely different types of detection system are possible. One, which might be called the volunteer system, depends upon a very large number of men so located that in the course of other work some of them can see and locate fires over the entire Forest area where risk is present and report them to the Forest officers. Such a condition is found on the Angeles Forest, where the area of highest risk is in the form of a narrow strip of steep mountains directly adjoining and visible from a large and very thickly populated valley. The advantages lie in the large number of volunteer watchers—so large that even if a smoke escapes detection by nine men there is a tenth present to see it—and its cheapness—no man receiving pay for the sole duty of watching for fires. It is exactly the detection system upon which a city fire department depends.

Lookout Service.

The other type is the continuous detection system, or lookout service, and employs a comparatively small number of paid men, each permanently located at a point giving the best view of a definite area and held responsible for the detection of all fires within that area, being provided by the Service with facilities for locating and reporting each fire that occurs. It is the only possible system for a large and sparsely populated mountain region. Its advantages are that it is closely tied in with the rest of the protection organization and under complete control by the head of that organization.

Comparative Test of Systems.

Which type is best for a given area is *not* "a matter of judgment depending on local conditions." The best type is the one that will render the best detection service at

a cost commensurate with the value of that service. Forest supervisors depending entirely upon a volunteer detection system will proceed to demonstrate the comparative value of that service by the following method:

An experimental lookout station of standard type and equipment will be installed with as little publicity as possible (in order not to curtail the volunteer detection service heretofore rendered). For every fire occurring in the area controlled by the station a comparative record will be kept of each one of the elapsed time periods from each type of detection system. After the station has been in operation a sufficient length of time, a decision on the comparative value of the two types will be made, based upon these records, the average acreage per fire in the control unit before and after installing the station, and the cost of installation and operation.

Because of the vast stretches of uninhabited country, lookout service is an obvious necessity on most of the National Forests in California. By listing our knowledge to date of how each essential feature of a detection system can best be met, it is possible to define a type of lookout station and describe the equipment and operation that will serve as a standard until further knowledge is gained.

Selection of Lookout Stations.

From the very nature of lookout service, the *right view* is the fundamental factor in selection of points. On the average California National Forest, from 12 to 14 topographic points usually offer lookout possibilities. The problem is to apply an accurate method of selecting the least number that will cover the area to be controlled. Each point has a perfectly clear-cut and certain field of vision. The field from each point must be located as it appears to the eye in relief, and then flattened into a plane and measured. From the top of each possible lookout point the boundaries of the area *actually seen* may be located by use of a compass and the best available map. The "*seen areas*," platted on a Forest map in different colored hatchings give a basis for comparing the advantages of different points.

Suppose two possible points appear equally advantageous. To get a sure measure of their comparative rating: Draw a 15-mile circle on the map with each point as a center, measure with a planimeter the "seen areas" of each, and divide by the area of the 15-mile circle. The result, which might be termed the per cent of vision, is a mathematical figure which may be used as a guide in the final selection of the point.

As opportunity offers, each supervisor will check by this method—for uncovered areas and excess duplication of service—the lookout points on his forest.

Towers.

No matter how well located a mountain may be, if its top is flat or even rounded off, the lookout man must walk around the perimeter of the top to take full advantage of its field of vision. Should he merely stand in the center, the rim would cut off the view of many square miles of area for which he is responsible and in which many fires may start. The same applies in the case of mountains where the timber comes up to the top or nearly to the top. To determine the elevation above ground at which the lookout man must be placed so as to make the surrounding country visible to him, two or more tangent lines may be platted across the top of the mountain, each one passing through the center point and down each side a short distance beyond the rim. Elevation readings with an Abeny level will give the data to plat each line in relation to the profile of the mountain. The length of a vertical line dropped from the intersection of the tangents will be the proper height at which the lookout man must be when on duty. (See fig. 2.)

In case of timber obstruction, if only a few trees block the sight, they may be cut down; if, however, there is a stand of timber coming to the top from one or all sides of a point, the above method may be applied by considering the surface formed by the tops of the crowns as ground surface.

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Where the lookout man must be placed above ground to secure full utilization of the visual possibilities of the topographic point, a tower is necessary. The alternative to the use of a tower will be the installation of a second station on another point to cover the country cut off from the first lookout by his own peak top if he is in a ground station. The deciding factors are comparative cost and efficiency of service.

Steel Towers.

Where a tower is found to be a necessity and its transportation to the desired point can be effected, the following type of steel tower will be the standard for use in District 5. A steel tower is selected for standardization because of its strength, rigidity, mechanical perfection, and safety, and because its long life is believed to make it the cheapest in the long run. The tower selected is manufactured by the Aeromotor Co., of Chicago, Ill., and is illustrated in figure 3. Its parts are held together by bolts and nuts, and for a foundation requires four concrete piers sunk in holes in the ground, in which the four corner irons are anchored with T joints. The largest

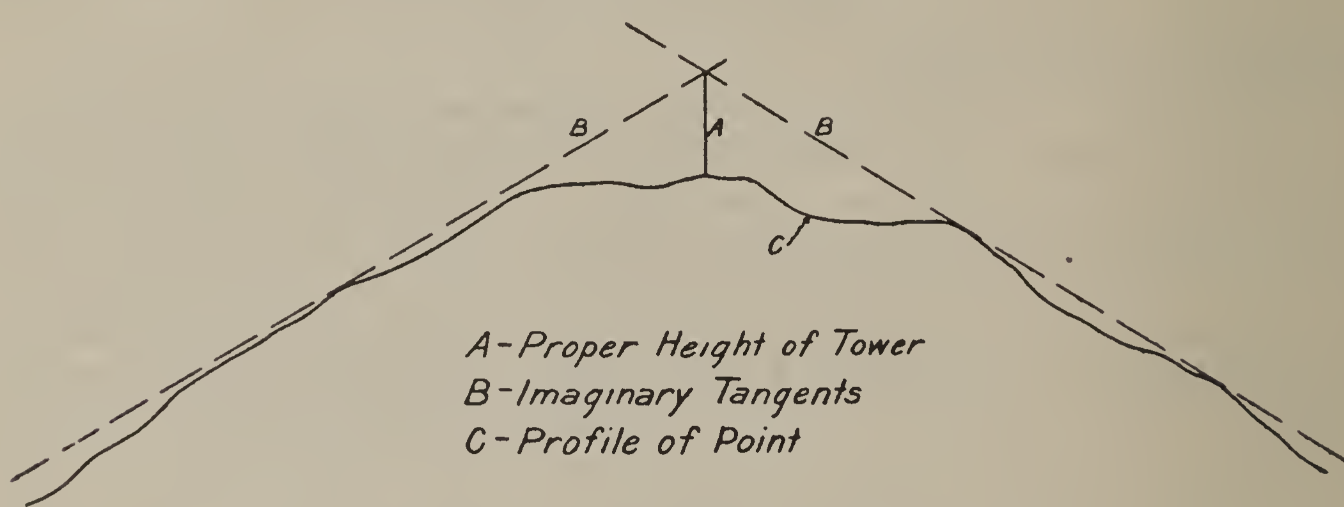


FIG. 2.—Method to determine height of tower.

single unit of the tower is 20 feet long and weighs 100 pounds. Prices and shipping weights are as follows:

Height of tower to floor of platform.	Weight.	Price f. o. b.—	
		Chicago.	Oakland.
Feet.	*Pounds.*		
50	4,000	$160	$220
60	4,450	180	247
70	5,350	215	295

Lumber Towers.

When a steel tower can not be delivered at a site, either pole or lumber towers will be used, depending on which material can be laid down cheapest in shape to start construction work. Lumber towers may be constructed according to the design shown in figure 4 at an approximate cost of $200 for labor, material, transportation, and subsistence for a tower 40 feet to the platform floor.

Pole Towers.

Pole towers may be constructed by selecting four poles, their diameter depending on the height of the tower, with as little taper as possible. After digging four holes for anchorage, two bents are made by cross bracing the two sets of poles by smaller poles with ends hewn flat, using large spikes. The bents are raised and set with a horse and block and tackle, and connected by cross braces. Practically the whole cost is labor, and for towers under 40 feet it should not run over $0.90 a foot. If it is not possible to set the tower legs in concrete, the ends should be charred or given some other preservative treatment.

House.

Towers must carry more than simply a platform and railing. A man can not be expected to remain all day on top of a windy peak in the glaring sun. The tower can

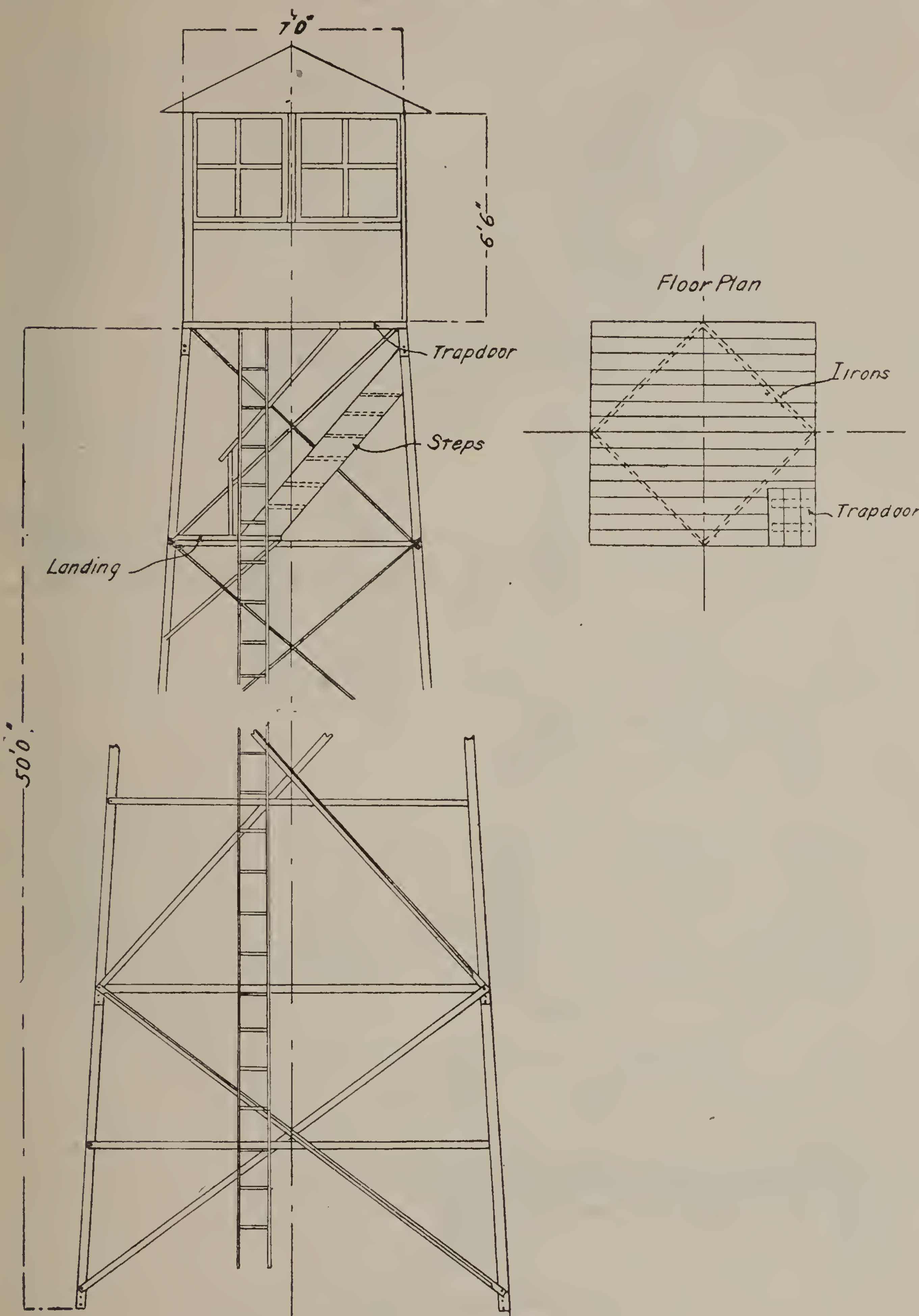


FIG. 3.—Steel lookout tower. (Can be supplied in 50, 60, and 70 foot heights.)

be capped with a house 6 by 6 feet, glazed all around for a width of 24 inches. This will allow for a fire locator, chair, pigeonholes, and telephone.

Special Factors Governing Location of Lookouts.

To meet the essential of proper location in relation to area controlled, the most mathematically correct method of lookout point selection may have to be modified and in some cases governed by conditions within the area for which the lookout point

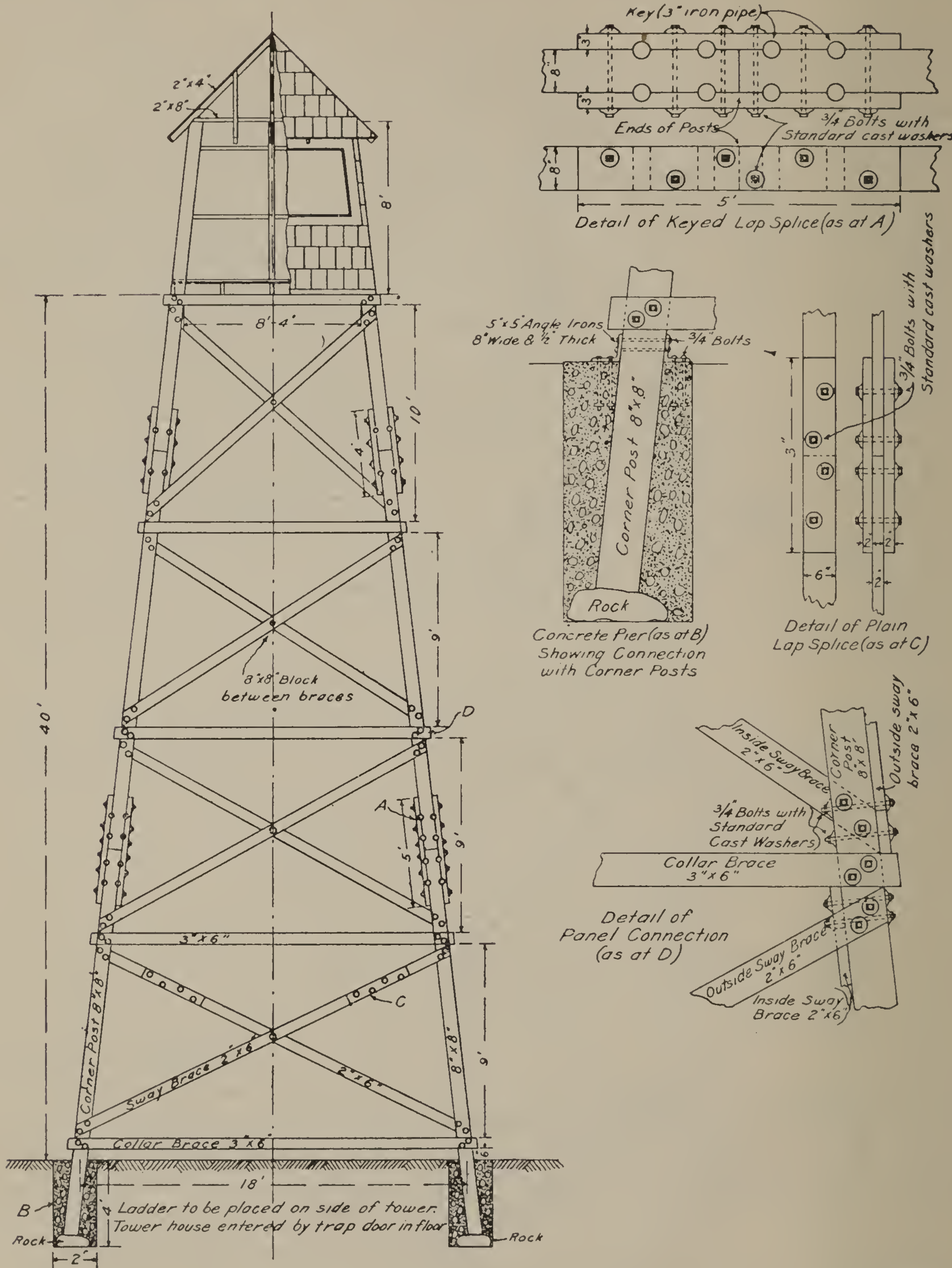


FIG. 4.—Structural design for frame lookout tower.

is the detection agency. Inflammability of cover, many and careless travelers, incendiary tendencies of residents, or prevalence of lightning may constitute a fire hazard so great that no portion of the unit can be shut off from the lookout's view by a topographic feature. This means a smaller unit. Transportation or communication

facilities—or the lack of them—may necessitate, temporarily at least, a departure from the ideal lookout selection.

Still another modifying factor in the selection of a lookout point is its location in relation to the sun. The sun's rays entering a darkened room reflect from the floating particles of dust to one's eyes in a manner which renders the sunbeam itself more visible than objects immediately behind it. This same effect, multiplied by several million, is the "sun glare" or "heat haze" which with the sun at less than 30 degrees above the horizon materially shortens the distance of effective vision toward it. Floating particles of dust, smoke, or moisture overhang the whole country in a blanket of nearly uniform thickness but of varying density. Over towns and populous valleys it is denser than over mountains and forests. The great valleys of California lie directly to the west of the long strip of the Sierra Nevada Mountains, and the effect is highly intensified in the afternoon with the sun in the southwest. The angle of incidence equaling the angle of reflection, it is obvious that the clearest possible view during the dangerous afternoon period will be afforded if the station is so located that the greatest portion of the atmosphere does not reflect the rays of the sun to the lookout's eyes. (See fig. 5.) By tests made on California lookouts, 1 to 3 has been found to be about the proper ratio between range of effective vision toward and away from the sun when less than 30 degrees above the horizon. After 3 p. m. a lookout could be de-

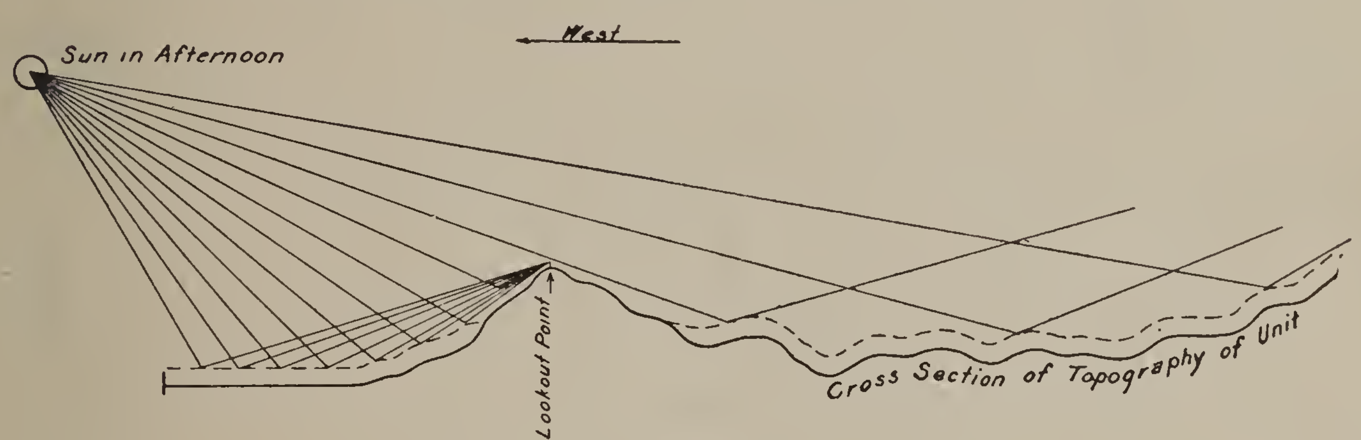


FIG. 5.—Obstruction to vision by sun glare.

pended upon to detect a fire northeast of his station three times as far away as one southwest of it.

For example: Assuming a control unit roughly circular and of uniform risk throughout, measuring 12 miles from the southwest to the northeast corner; then from a point in the diagonal 3 miles from the southwest corner a lookout-man could see over this 3 miles to the southwest edge as well as he could over the 9 miles to the northeast edge of his unit. (See fig. 6.)

There are, then, three points which must be studied and weighed before deciding upon the location of a permanent lookout station—its range of vision and the correlation of its range with that of other points, the type and cost of the structure necessary to secure full utilization of its visual possibilities, and its location in relation to the sun.

Continuous operation, accurate location of fires, and immediate report depend first upon the man on the lookout point, and, second, upon the facilities furnished him by the Service for his work.

Lookout Personnel.

The mental or psychological phase of lookout service is immensely important, because the starting into action of our whole control system—no matter how well geared and polished a machine we have—rests squarely upon the shoulders of a plain man, just as human as any one of us. And what is more, a human under two kinds of strain—constant and unchanging responsibility, and living apart from his kind. Lookout work day after day (Sundays included), with its unnatural strains, requires unusual mental qualities in the man, and anything like an exact measure of a man's mental

make-up is hard to get. He should possess perfect saneness, phlegmatic temperament, poise, and an imagination well under control. Strong sense of humor is a most valuable asset.

Lookout Reliefs.

To do everything possible to relieve the strain and make things more bearable for the man on top is plain business necessity. The lookout-man should be allowed four days every month entirely free for recreation. This should be so arranged that in each month not less than two days come together; and the lookout should be allowed to do anything he pleases during his relief periods. A definite schedule should be made at the beginning of the season to provide for lookout reliefs by other members of the control force. Liquor should be prohibited on all lookout points.

Forest officers should visit the lookout man frequently. Such visits should be carefully scheduled, so that no long periods intervene. Forest travelers and campers

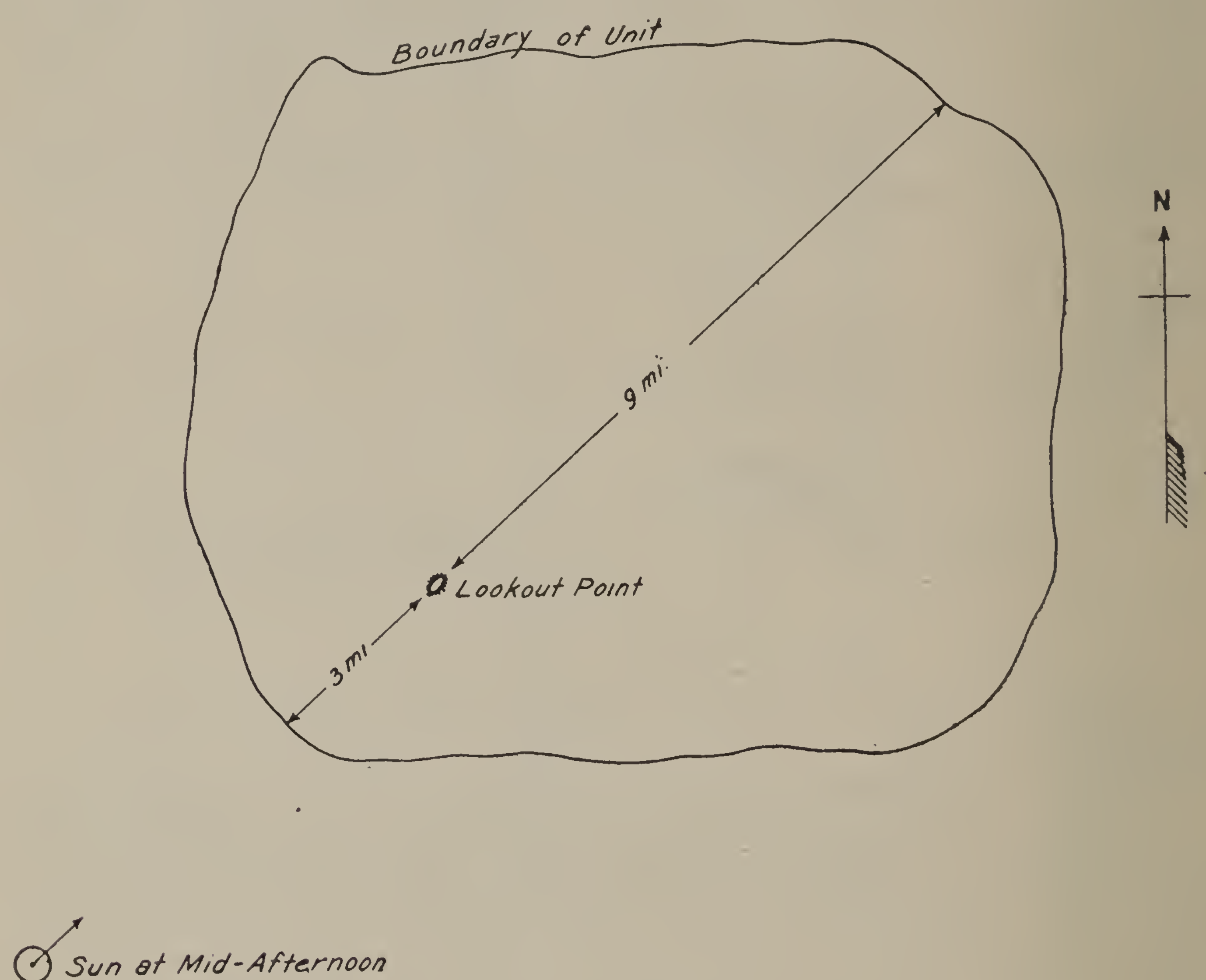


FIG. 6.—Ideal location of lookout in relation to sun.

should be induced to "go up and see the lookout point." Their natural curiosity can in this way be taken advantage of. A systematic collection and delivery of magazines, books, and newspapers should be put into effect by rangers and the supervisor. In the evenings excellent use can be made of the phone. The other men should call up the lookouts at night and tell them the gossip of the day. Give them switches and right of way in the use of the phone at night. See that they get the news of the fires they report. Rangers of musical bent (and many of them are) may rig up a paper horn on the telephone transmitter and cut loose with a fiddle or banjo. A graphaphone is good, too.

There are certain obvious advantages in securing for lookout duty a married man who will take his wife to the station with him. Reliefs need not be as frequent, and the psychological difficulties engendered by solitude, eyestrain, and responsibility are materially lessened. Suitable living accommodations should be provided and

encouragements given wherever necessary to induce a man and his wife to occupy a lookout station.

A prospective lookout man should be given an eyesight test by the supervisor or district ranger before he is definitely employed, preferably from a high point with a wide view.

From the Service standpoint, the lookout man should have highly developed the power to size up the whole field of vision and pick out from it quickly and surely the contrasts, varying from sharply outlined columns of smoke against a black timbered ridge to indefinite and dimly visible spots of haze against the background of blue sky. This can be done best with the naked eye. The art is entirely comparable to sighting land from a ship at sea. The trained sailor drags his line of vision slowly along the horizon, not focusing his eyes at any one point; a contrast appearing, he focuses his eyes upon it. It is this trick that enables the sailor to pick up a shore line at twice the distance a landsman can.

Station on Summit.

To guarantee continuous operation, the eyes which should see every fire the moment it starts must be at the point from which the entire control unit can be seen from earliest daylight to black dark. In order to make sure that those eyes will be nowhere else, the lookout cabin must always and under every condition be placed squarely on top of the lookout point. Under no other circumstances can service be continuous. If the peak is too sharp to afford room for the lookout cabin, its top must be dynamited off. The expense of preparing a house foundation on the very top of some peaks may be high, but it is a part of the legitimate cost of the station.

With the living quarters 400 yards away from the point of observation, it may be assumed that the lookout man will arrive on the peak not earlier than 7 a. m. He brings a lunch and a canteen of water, and does not leave at noon but returns to the cabin to cook his dinner at 5.30 p. m. Such a station is unmanned and useless to the organization below during four hours of daylight every day—aggregating eight and one-half days a month—and this waste period, during which a fire might be burning and the whole control organization unaware of it and idle, is not the fault of the lookout man but of the officer who located the station. The location of lookout stations squarely on top of observation points will be established, then, as a definite district standard.

Construction of Lookout Stations.

Bearing in mind the purpose of the station and its relation to the protection scheme, the following broad principles can be applied to the construction of lookout stations, suiting details to the demands of each locality.

1. Living quarters and working station will be combined.
2. Stability of the building is essential.
3. The comfort of the occupant must be provided for.
4. The maximum view must be obtained from inside the building.
5. Insulation against lightning must be provided.
6. The interior arrangements must be adapted to the purposes of the station.

Construction of Cabin.

The lookout man's dwelling, office, and workroom should be centered in one house, on one floor, and in one room. The room can not be less than 12 feet square, and must be so constructed that at any moment of the day, with a turn of the head, he can see his whole field. He must be fixed so that while he is cooking, eating, reading, writing, dressing, washing his clothes, walking about, or sitting down, he can not help but be in the best position to see.

No one class of building is subjected to the exposure and strain that lookout houses must stand up under. Every one needs a solid foundation. Concrete or masonry, in which are embedded heavy bolts for anchoring sills, may be necessary in some cases. Timbers should have one and one-half times the cross-section area of those used for

ordinary buildings, and each house should be well guyed with light cable against the winter storms.

Remember that we are providing shelter for men in extremely exposed positions, and comfort is therefore essential to the results we demand of them. The house should be wind and rain proof, but at the same time should provide ample ventilation for the hot days. For the sake of eye protection, the interior should be painted dark olive drab in accordance with the district standard color scheme, and outside projecting sunshades should be provided for the windows. The building should be equipped with a good cooking stove and a bed with springs and a comfortable mattress.

The aim should be to make the view from the inside of the house as comprehensive as that secured from the same point without a house. The ideal is a transparent strip clear around the house, its center at the height of a man's eyes when standing. Obstructions such as vertical braces, sash frames, stove pipes, or furniture must be reduced to a minimum. To get this result, steel T, **I**, or L beams can be inserted in the vertical supports except on the four corners. The 26-ounce plain glass will serve all window purposes.

Lightning insulation will be secured by following in detail the methods described in Farmer's Bulletin No. 367, United States Department of Agriculture, Lightning and Lightning Conductors. Particular care should be taken to secure satisfactory grounding of rods.

Furnishings.

Furnishings for the house—the fold-up bed, stove, wood box, washstand and towel rack, dining table, cupboard for clothes and personal belongings, and the cupboard for cooking utensils and provisions—must all be so designed as not to project above the window sills. The top of each piece of furniture must be less than 42 inches above the floor. The windows—or more properly, the ribbon of glass—should be 24 inches wide and set at a height that will admit of a good view all around when the lookout man is on his feet. When he is sitting (except at meals) his position should be elevated so that his eye is on the same level as when he is standing. This can be accomplished by constructing in the center of the room a platform about 4½ feet square and 27 inches high. Half of this platform is occupied by the lookout man's table, desk, telephone, and fire-locating apparatus. The other half is occupied by a revolving chair.

Such a station should require about the material given in the following estimate:

TABLE VIII.—*Sample estimate for lookout station.*

1,152 feet b. m. rough common lumber, at $23	$26.50
550 feet b. m. surfaced clear lumber for flooring and ceiling, at $40	22.00
350 feet clear rustic siding, at $60	21.00
3,000 shingles, at $2.75	8.25
12 windows, at $3.80	45.60
Masonry foundation (4 yards)	28.00
Cable, turn buckets, etc	4.15
Hardware	4.00
Carpentry labor, 2 men, 4 days	24.00
Paint and painting	22.50
	206.00

Figures 7 and 8 give a typical elevation and plan of the standard station.

Fire Locator.

A considerable degree of accuracy in determining the location of fires sighted is often obtained from the lookout's general knowledge of the country his station overlooks. But what is wanted in all cases is the nearest approach to mathematical certainty that

can be obtained quickly. Angle readings from two points would accurately locate fires at the intersection of the two lines of sight, presupposing an accurate map in the office to which the readings were reported; and no device would be necessary on the lookout points except one that would read angles. But many fires start which can be seen by only one lookout. The essentials of the locating device at each station should be, then, a map of the Forest accurately oriented; a circle on the map graduated to degrees and centering on the point; a revolving straightedge equipped with front and rear sights, the rear sight pivoting the lookout point on the map; a straightedge graduated in miles on the scale of the map. The best device is the one that combines these

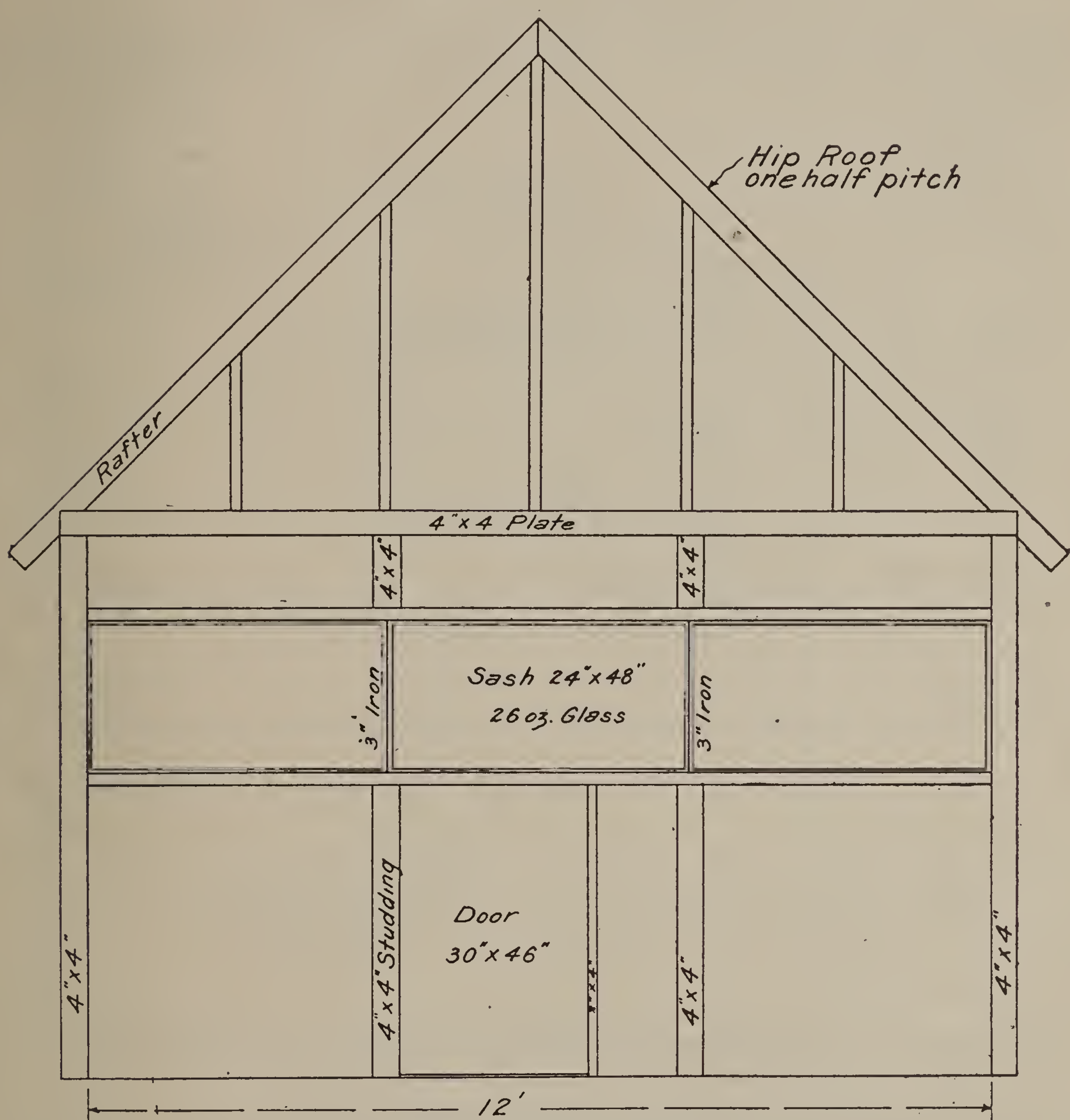


FIG. 7.—Inside elevation of lookout station.

essentials in the simplest way, and is at the same time quickest and easiest to operate and costs least. It is immediately apparent that an adapted form of the regular sight alidade in combination with a mounted Forest map is the basis of the ideal lookout fire locator. A study of all the devices in use in California eliminates all but one for various defects—excessive cost, liability to error, complicated construction, or inability to permit sights on a deep angle of declination. The device selected for standardization in District 5 is the Godwin fire locator. (See figs. 9 and 10.) It meets the essentials with the minimum number of parts and is easily and quickly operated by a man unfamiliar with the use of instruments. The whole locator, including mounting

the maps on the board and shellacking can be made locally and should cost about $2.50. One degree graduations from 0° to 360° should be drawn in red on the margin of the map. When the area controlled by the station is less than 44 by 23 miles, the map should be on a scale of an inch to the mile.

This locator should be used in the standard lookout houses or towers. The table shown in figure 10 is the same as that in figure 7 and must be carefully oriented (generally by the supervisor to make sure of this important point) before being used for the locator. As will be noted in figure 9, the top of the table is made with a depressed area 3 inches wider and 3 inches longer than the largest board. When the board is flat against any side or sides of the depression it will be in orientation. This possible shift-

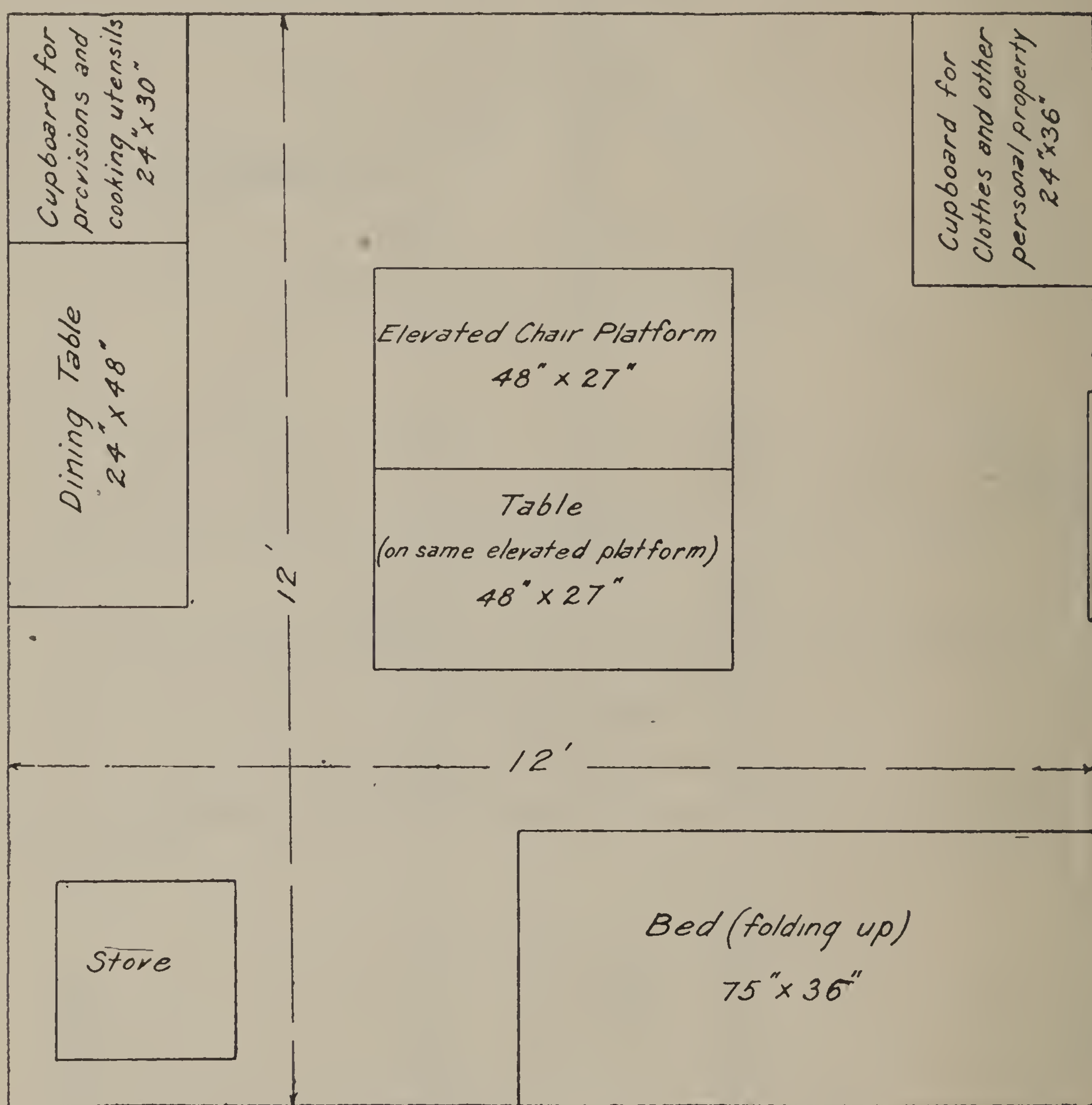


FIG. 8.—Arrangement of interior of lookout station.

ing of the board allows the observer to throw out of the line of sight such obstructions as corner posts and window sashes. Pending the erection of a lookout house or tower, the locator can be set on a stationary tripod on which is screwed an oriented iron plate. The three holes bored in the under surface of the board fit over the three lugs on the plate.

Lookout Maps.

In order that he may understand clearly the organization of which he is so vital a part, each lookout should be furnished with a wall map of the whole Forest (on a scale of one-half inch to the mile, so it will hang below the window sill) showing, in addition to data of roads, telephones, tool caches, patrol divisions, etc., the exact area dependent on his own station, and the other lookout stations and their areas of control. The

lookout points should be furnished with protractors and threads. The wall map should also show each guard's location and his duties in sufficient detail to tell where he can be reached by phone at a given time of day.

The most efficient device for quick determination of intersecting lines of sight at the headquarters of any officer receiving reports is a well-mounted large-scale Forest map on which are black threads which can be stretched from each lookout station to represent such lines. The map should be mounted on a true surface, such as a soft pine drawing board, and marked with the accurate location of lookout points. About these points should be inscribed circular protractors, graduated in degrees from 0° to 360°—the same graduation used by the man on top. When the bearing of a fire is given, the thread can be stretched over the proper degree mark and held taut on the edge of the map by a small catch. Such a catch can be made of an old rubber stamp with two needle points inserted in the rubber face and protruding

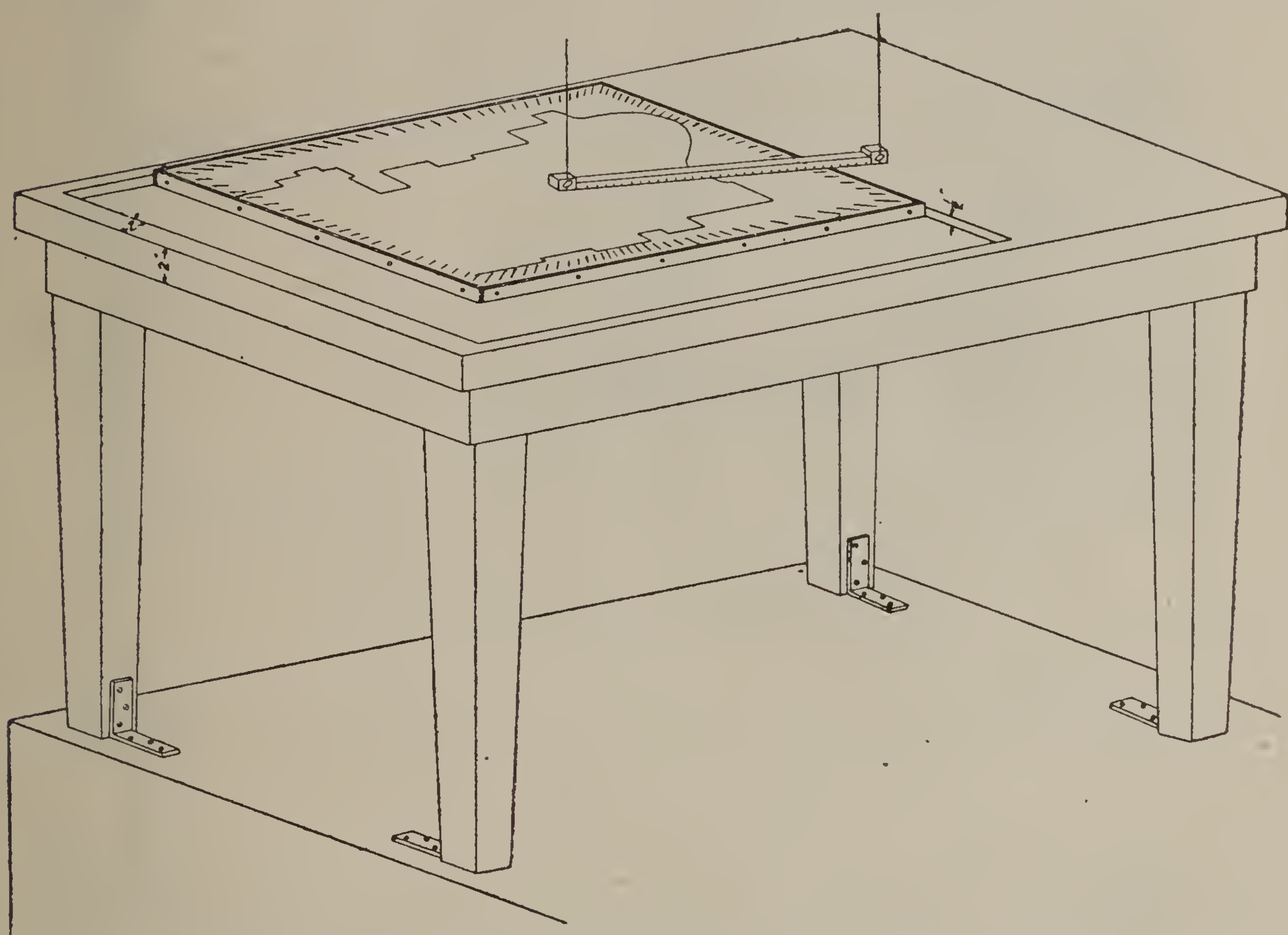


FIG. 9.—Godwin fire locator. (Board may be used on tripod or table.)

about ¼ inch. With such a device it is possible to clamp the thread at any point along its length.

Lookout Telephone.

For purposes of communication the station must be equipped with a telephone or a heliograph instrument, possibly both. In any kind of a lookout *house* the desk-set type of phone should be installed, the wires brought in under the house and up under the lookout man's table or desk. He will then save the time lost in jumping up and going to the wall, and running back and forth between map, locator, and phone. He can talk and look at map and locator all at once.

Field Glasses.

As has been said, the naked eye is best for the original detection of rising smoke. Glasses are of great assistance, however, in examining a suspicious haze once it is discovered, determining its nature, the character of cover it is burning in, the direction of the wind, and the velocity of the fire. Field glasses are now furnished on requisition from Ogden. Further tests and demonstration is necessary before a more expensive type of glass can be used.

Goggles.

Protection from eye strain is necessary. Before this was realized more than one lookout man had his vision seriously affected. The damage is done by the violet rays in sunlight, and the glass must therefore be amber color, which eliminates these rays. After trying a number of kinds, the "La Fenetre" goggles, made by Abercrombie Fitch & Co., of New York, have been found to be the best practicable glass and their use will be standardized. This goggle is made from one piece of oblong

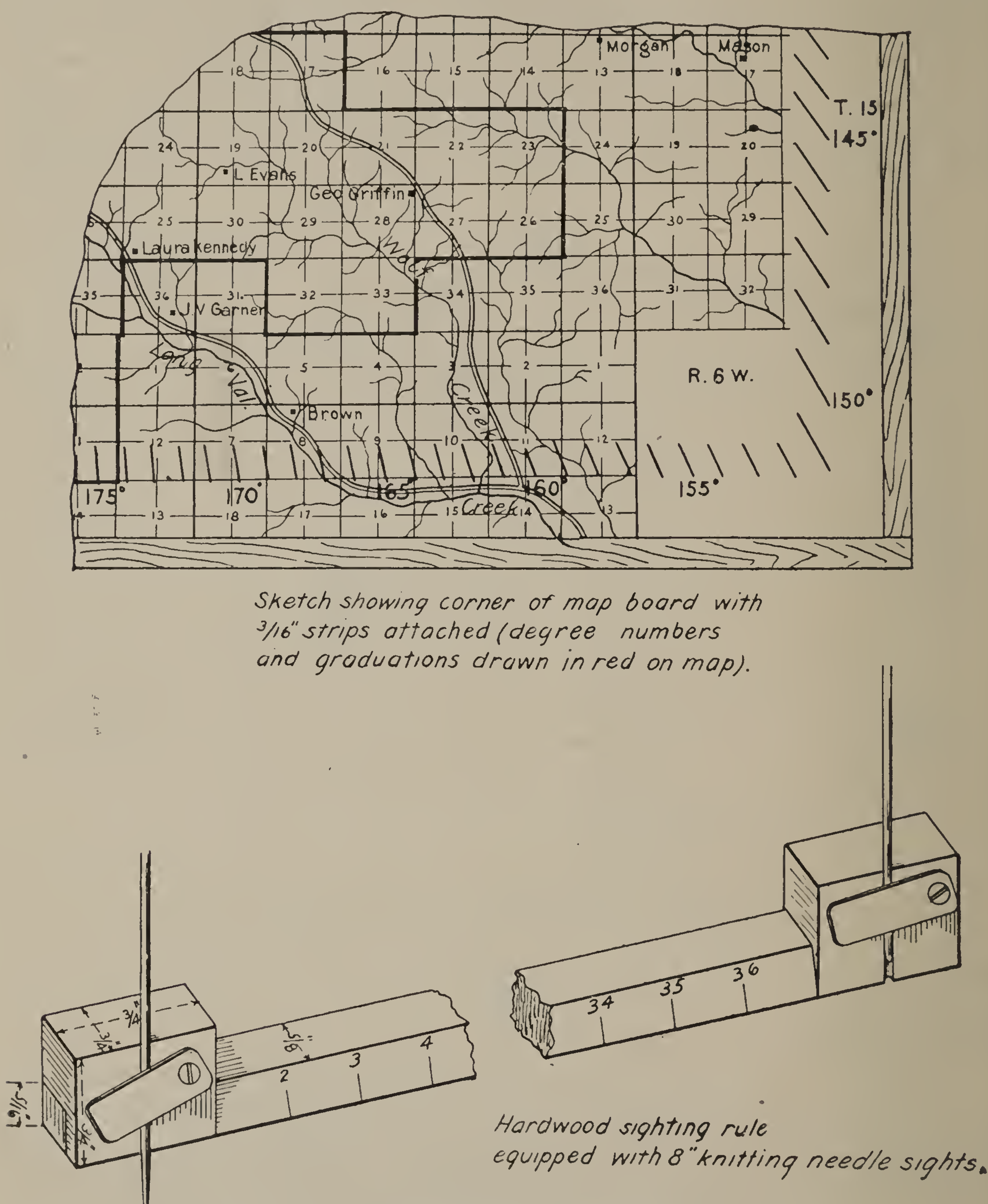


FIG. 10.—Details of construction of Gedwin fire locator.

curved amber glass. The effect is much the same as looking out of an amber window, since the nosepiece, a common source of eye strain, is absent. They cost $2.25 per pair.

Ration.

Whenever necessary to secure continuous service, lookout men will be subsisted by the Forest Service. This also insures the right kind of food and its proper delivery. Regular arrangements should be made for having supplies packed in by guards. The following is a suggested lookout's supply list for one month, and for the purpose of determining rates of pay may be figured as costing $19.

TABLE IX.—*Lookout's supply list.*

[One man one month.]

Bacon	pounds	6
Ham	do	10
Lard	pounds (can)	5
Flour	pounds	20
Mush (H. O.)	do	2
Cream of Wheat	do	2
Macaroni	do	3
Baking powder	do	1
Sugar	do	10
Sirup	gallons	½
Coffee	pounds	3
Tea	do	½
Chocolate	do	1
Milk	cans	10
Butter	pounds	4
Dry fruit:		
Apples	do	2
Prunes	do	2
Apricots	do	2
Beans	do	4
Rice	do	2
Potatoes	do	20
Pepper	ounces (can)	2
Salt	pounds	1
Onions	do	5
Catsup	quarts	2
Crackers	pounds	3
Cheese	do	1
Corn, canned	cans	4
Tomatoes, canned	do	4
Fresh meat, fresh fruit, or special relishes	dollars' worth	3

The last item is an addition to regular guards' or crew laborers' ration lists, and is intentionally added to help toward "job content" on the part of lookouts.

When necessary, in order to avoid breaks in the continuity of service, arrangements will be made to deliver wood and water at the lookout station.

Wood.

Wood for fuel should be packed to the lookout station periodically by patrolmen, visiting rangers, or men hired for that purpose. The wood should be stacked close to the house or against the house in a wood box which has a trapdoor opening into the house.

Water.

A lookout man must have plenty of good water, and he can not put the station out of commission while he does his own fetching. Very seldom is there a good supply nearby the station site.

Tanks.

The galvanized-iron storage tank for snow water will be the district standard wherever conditions will allow it. These conditions are simply the presence of a snowdrift within 500 feet of the lookout point on April 1, or even earlier, and reasonably cool nights all summer. A 1,600-gallon galvanized-iron tank, with an outlet pipe in the bottom and an intake pipe near the top, is installed under a tight shelter near the lookout station. The intake pipe is run back to the snowbank and into a reservoir made by a small dam to catch the melting snow and divert it into the pipe. If the tank can not be filled by gravity, a hand pump may be installed. A patrolman visits the lookout station at the latest possible date in the spring, fills the tank and closes up the shelter. Drawn off gradually from the bottom, the water will keep sweet all summer. The lookout empties the tank when he leaves in the fall. (See fig. 11.)

The following should be about the costs:

Galvanized-iron tank, capacity 1,600 gallons	$35.50
4 ¾-inch nuts (lock nuts)	.80
2 blacksmith-made iron punches, at 50 cents	1.00
8 days' labor, at $2.50 per day	20.00
Freight and transportation to place	10.00
	67.30

When a mechanical water supply is out of the question, water may be packed by guards or laborers to the lookout station. Four 5-gallon water bags (weight, full, about 160 pounds) make a load for an ordinary pack animal. No specialized water-packing equipment is necessary. A tight barrel should be kept at the station for reservoir purposes.

Records.

Lookout records have one primary purpose to serve—to secure data for studies on discovery time and report time. They also serve as meteorological data. A secondary purpose is to give the lookout something to exercise his mind upon and keep up his interest in his work.

FIG. 11.—Lookout water supply. (Snow water storage.)

In every case where the subsequent history of a fire brings out the time and the point at which it started, this information will be furnished the lookout for a current check on his own discovery time and accuracy of location.

False Fires.

In order to save wear and tear on the lookout's nerves, and for the information of new men or relief, "false" fires and "legitimate" smokes should be listed with their bearings and posted on the walls of the station. By "false" fires are meant gray rocks, scars in hillsides, or white tree stubs which, with the sun at certain angles, look exactly like a thin haze of smoke rising. "Legitimate" smokes are towns, smelters, sawmills, or donkey engines. The lookout should be kept posted on any long moves of the latter.

Organization.

The supervisor is, of course, responsible for the primary organization of the lookout service. He will also be responsible for the selection and correlation of the points. The lookout man himself, though a part of the ranger district organization, should in every possible case be examined as to mental qualifications and eyesight by the supervisor before being definitely employed. Since the ideal is to get word of a fire to the man who is to go to it as quickly as possible, the fewer steps there are in the transmission of that message the less time will it take. Whenever a lookout knows that

he has accurately located a fire without a cross shot from another lookout, and can phone the right member of the control force direct, he should do so. The district ranger should keep the lookouts in his district posted on just where each man can be reached by phone and just what area each is covering. If this is reasonably fixed, the points and areas should be drawn on the lookout's map.

When a cross shot from another lookout is necessary to locate a fire accurately, or when the patrolman can be reached more quickly by phone through the district ranger, the lookout should report to him first. In any case the district ranger should be given all of the facts concerning every fire that starts, including the action taken by the lookout, just as soon as possible. The district ranger will make the necessary reports to the supervisor.

Lookout stations will also be inspected by the district forester or his direct representative for conformity to standard practice and correlation of service between Forests.

Time Standard.

Speed and accuracy in detection, location, and report are the two yardsticks with which to measure lookout efficiency. Strict maintenance of the highest possible standards in discovery time and report time are essential to effective lookout service. A reasonable average standard for discovery time can not be established at present for lack of sufficient data on which to base it. It will be established as soon as the necessary studies can be made. Eight minutes will be set as a reasonable average report time standard, and the location of no fire reported should be missed by over three-eighths of a mile.

Immediately upon sighting a suspicious smudge the lookout should endeavor to connect with the officer to whom the report is to be delivered. He may have to hold that officer at or near the phone for a few minutes while he is making sure whether it is a fire or not, but this preliminary report may save the Forest fireman just the few minutes he would need to prepare to go. Discovery time will be figured from the minute the fire starts to the minute the lookout starts to ring up (or sight his heliograph) for either preliminary or certain report of a fire. Report time will be figured from the minute the lookout starts to ring up to the minute the man who is to go to the fire says, "I understand. Good bye."

Emergencies.

There are three agencies which may put the lookout service entirely out of commission: Drift smoke, fog, and lightning. The first is the great problem where the control unit is adjacent to logging operations where summer slash-burning is practiced, as in the redwoods of California. Drift smoke usually works slowly up the main canyons, finally filling all side gulches and ravines. The whole mass then slowly rises on a level until often the highest peaks are enveloped. Or, if the source of the smoke is closer, the whole atmosphere gradually thickens slowly, shortening the distance of effective vision. The only thing to do is to increase the number of Forest firemen and riding patrol, supplementing if necessary with emergency control men. Fog often cripples the service in the same way, and requires the same precautions. But with fog the fire danger is generally lower.

Lightning.

In spite of the best lightning insulation that can be given a station, even the best lookout men may not remain in the house on top during a bad storm. Nor can they be blamed. Of course, in the case of a steel tower, to stick out a bad lightning storm would be foolhardy. Lookout service thus suffers at a time when it is needed most. Luckily, most such storms are of short duration, and the lookout gets back on the job in time to catch resulting fires.

CHAPTER XI.

COMMUNICATION.

Time Element.

A careless camper riding along a road bordered by big sugar pines with needles and squaw carpet underneath lights a cigarette and flips the match away before the sulphur is entirely burned out. It ignites a couple of pine needles, but the camper does not notice that and goes on his way. A hundred yards away from where the match struck is the edge of an old logging slash, and the fire, now fully started, is advancing toward it, we will say, at the average rate of 12 feet per 10-minute interval, as follows:

In the first 10 minutes, 2 feet.
In the second 10 minutes, 5 feet.
In the third 10 minutes, 9 feet.
In the fourth 10 minutes, 15 feet.
In the fifth 10 minutes, 30 feet.
In the sixth 10 minutes, 50 feet.
In the seventh 10 minutes, 70 feet.
In the eighth 10 minutes, 100 feet.
In the ninth 10 minutes, 140 feet.
In the tenth 10 minutes, 180 feet.
In the eleventh 10 minutes, 220 feet.
In the twelfth 10 minutes, 260 feet.
In the thirteenth 10 minutes, 300 feet.

Assume that a fireproof line 2 feet wide in the edge of the uncut timber will head it out of the slash and hold the fire, and one man could rake it clean at the rate of 20 feet per minute.

The protection system that can keep that fire out of the slash must contain a unit that will see the fire, locate it, communicate its location to a second unit, who must acquire a tool and a means of transportation and travel to the point on the edge of the timber where the line must begin. The fire will have a 300-foot front when it reaches the timber 120 minutes after it starts, consequently 15 minutes will be needed to rake a line that will hold it. The four processes of discovery, location, communication, and travel can not take more than 105 minutes altogether. If the fire does not make smoke enough to be seen until it is 15 feet square, which takes 40 minutes, and 50 minutes are taken up in travel, the information in regard to it must be transmitted in not more than 15 minutes. If communication between these two units was indirect, or if more units had to be brought into action, a correspondingly less time per message could be allowed.

Purpose of Communication System.

The primary purpose of a forest communication system, then, is to bring into action the protection forces. Within the area of class A fire danger it is possible for fires to occur at any point and at any time of day or night during the dry season. The forces that must be brought into action for every fire may consist of 1 unit, as in the case described, or of 20 or 30 units, as in the case of the San Bernardino fire of 1911. In the majority of cases each of these units occupies a separate point at a given instant of time.

The following shows in tabular form what units must be placed in communication:

TABLE X.—*Communication needs for each ranger district.*

Unit.	Consists of—	Needs communication in the following order with—
Supervisory force	District ranger	(1) Lookout; (2) forest firemen; (3) patrolmen; (4) supervisor; (5) forest crews; (6) volunteers.
	Supervisor	(1) District ranger; (2) lookout.
Suppression force	Forest crews	(1) Forest firemen; (2) district ranger.
	Volunteer control organization	(1) Forest firemen; (2) district ranger.
	Fire fighters	(1) Other parts of line; (2) district ranger.
	Firemen or patrolmen at fire	(1) Lookout; (2) district ranger.
Control force	Forest firemen	(1) Lookout; (2) district ranger; (3) volunteers; (4) forest crews; (5) patrolmen.
	Patrolmen	(1) Forest firemen; (2) lookout; (3) district ranger.
Detection force	Lookout	(1) Forest firemen; (2) patrolmen; (3) district ranger; (4) supervisor.
	Volunteer detectors	(1) District ranger.

Essentials of Ideal System.

The best communication system is the one which provides the simplest means accurately to exchange information with the highest number of points occupied by protection forces in the shortest time all of the time and for the least cost.

A discussion on communication systems in their relation to forest-fire protection too often becomes a treatise on telephony. Now telephony is a technical science in itself, far more so than fire protection, and it has its own literature and its own experts, both available to the Forest Service. For our purposes what is needed is a brief discussion of each mechanical method of communication, a statement of the protection uses to which it may be put, the conditions under which and the shape in which it may be used and specific references to the best literature on each subject.

There are only two senses through which a man may receive from a distance information about protection work—hearing and sight—and all methods must transmit either by audible or visible signals. Audible signals may be made by explosives or electricity; by the former in the shape of shots or blasts and by the latter in the shape of letter sounds or the human voice. Visible signals depend upon the eyesight and must be sufficiently large or sufficiently bright to be distinguished at great distances. They may take the form of specially shaped objects which have predetermined meanings or of letter signs.

Sound Signals.

For signaling purposes dynamite blasts and revolver shots are the only two sufficiently loud that, at the same time, require an equipment to explode sufficiently light to consider. Shot signals have but one practical use—to move men on a big fire line. For any other use, for signaling the discovery of a fire from a lookout, or for sending for additional help on a fire, they can not be made to convey sufficient information and they are not sufficiently dependable. For these purposes, other and better methods can be found.

But sad experience in some of the big fires in the brush belt—the San Bernardino fire, the Sycamore Canyon fire, the Tejunga fire, and particularly the Tamalpais fire—show the imperative need of adopting and adhering strictly to a system of sound signals designed to safeguard the lives of the men at work on the line. Revolver shots require the equipment that is least inconvenient to carry while working and can be heard over the length of the average large fire line. They will therefore be used. The signals must be simple, few in number, repeatable any number of times without confusion, and generally known. Everyone who goes onto a fire line should be instructed in them.

Safety Signals.

The following system of signals will be adopted for use by Forest officers in this district. The officer in charge of fire fighting will be required to carry a revolver:

– – – – (a series of any number of single shots with intervals of not less than two seconds between each)="The fire is in dangerous condition. Escape by running *down hill*."

–– –– –– –– (a series of any number of double shots with intervals of not less than two seconds between each pair)="The fire is in a dangerous condition. Escape by running *up hill*."

–––––––– (a series of more than two single shots, generally the gun-full, as close together as possible)="Assemble at this point."

Telegraph Not Suited.

The telegraph, both wireless and metallic circuit, obviously fails to meet the essentials of a protection communication system. It requires delicate, specialized, and expensive instruments and equipment; a continuous supply of chemicals not generally obtainable, or else an engine and motor to generate the sending power; it requires special training on the part of everyone who uses it, and has a wide possibility of error.

In theory the wireless telephone most nearly meets the essentials of the ideal forest communication system. It transmits the human voice, the quickest and surest medium of exchanging information. It connects as many points as there are stations. Its carrying agency—the air—costs nothing, is everywhere, and can not get out of order. It is ready for service, both sending and receiving, as long as the power is present to generate electricity of the necessary voltage. This last point, however, is the one which, at its present stage of development, unfits the wireless telephone for use in the mountain forests. A gasoline motor of at least three or four horsepower and a complicated and costly mechanism are necessary to send messages. A comparatively simple apparatus can receive them, but each point in our communication system that is not both a sending and receiving station is only 50 per cent efficient. Investigations and possibly experiments will be continued under the direction of the district office in the use of wireless equipment.

This brings us logically to the consideration of the telephone and wire system. When the Forest Service took charge of the National Forests nine years ago, it found its greatest handicap in fire protection to be the lack of facilities to call into action such protection forces as then existed. These were composed mainly of the ranchers adjacent to the Forests, many of whom were at the terminals of commercial and cooperative telephone systems. It was immediately obvious that if these citizens were to be depended upon for fire suppression, their own means of communication must be extended on up into the Forests where the fires occur and where the men were located who must call them out.

As more money became available and Service-paid prevention forces, rather than volunteer suppression forces, came more and more to be depended upon, the same means of communication were extended to tie together our own organization.

Telephones.

The construction of each Forest telephone system was generally considered to be a local problem to be worked out by each Forest organization for itself. The result is that the 3,000 miles of Forest Service telephone system in District 5 is constructed of many sizes of wire strung in many different ways; one particular style of instrument is put to many different uses and its units operate at varying degrees of efficiency or inefficiency. Telephony is an exact science, and in consequence the manufacture of the equipment demanded by it is an exact science also. Skilled engineers have designed each piece of telephone equipment for a specific use. To take advantage of this knowledge as far as possible each use in connection with protection communication was described minutely to a telephone equipment engineer who for each designated a specific piece of equipment as meeting it best. The standard list resulting is shown in Table XI.

TABLE XI.—*Standard list of telephone equipment, District 5.*

Material and uses.	Description of equipment.
Wire:	
Line	No. 9 B. W. G.–B. B., galvanized-iron wire.
Emergency	No. 20 emergency wire, consisting of 10 strands of No. 30 B. & S., hard drawn copper wire, insulated.
From line to fuse	No. 14 B. & S., rubber-covered, braided, waterproof copper wire (tested). This can be secured in single or twisted pair.
From fuse to protector	No. 14 B. & S., rubber-covered, braided, weatherproof copper wire (tested). This can be secured in single or twisted pair.
From protector to all inside apparatus, including phone.	No. 19 B. & S., rubber-covered, braided, inside telephone wire (tested). This can be secured in single or twisted pair.
From protector to ground	No. 14 B. & S., rubber-covered, braided, weatherproof copper wire (tested). This can be secured in single or twisted pair.
For attaching wire to poles:	
Brackets	12-inch oak bracket, creosoted. (Attach with one 40-penny and one 60-penny galvanized-iron wire nail.)
Insulators	No. 29 Pony glass insulators, 14½ ounces (deep groove).
Tie wires	No. 9 B. W. G.–B. B., galvanized-iron wire.
For attaching wire to trees:	
Fastener	5-inch galvanized-iron tree hook. (If these are not procurable through district office, use 4-inch wrought-iron staple for soft wood, and 2-inch wrought-iron staple for hardwood.)
Tie wire	No. 18 standard steel strand galvanized wire. To be used with ¼-inch galvanized-iron oval thimble.
Insulator	W. E. No. 37 split tree insulator, improved.
Bracket	When solid ties are necessary, 8-inch galvanized Pierce steel pin. with drivescrew, W. E. No. 102759.
Insulator (for above)	No. 29 Pony glass insulator, 14½ ounces (deep groove).
Instruments:	
For supervisors' offices	Desk set, W. E. No. 1300–N. Desk stand, W. E. No. 1020–S. C., with No. 143–W receiver. (A double-head receiver W. E. No. 147–W, with cord, in addition to the regular receiver is a great help in long conversations, and in offices where there is considerable noise.)
For district ranger stations	Do.
For other ranger stations	Telephone wall set W. E. No. 1317–S.
For patrolmen's stations	Do.
For patrol routes	Weatherproof iron box telephone, W. E. No. 1336–J. (With this box should be used a weatherproofed metal switch and protector mounting box, to be ordered from the A. G. Electric & Mfg. Co., of Seattle.) Patrolmen whose routes follow telephone lines should be equipped with Forest Service portable telephone No. 1375–A, and the necessary attachments as described below.
For fireman stations	Telephone wall set No. 1317–S. Extension mine set with 6-inch gongs, W. E. No. 292–U.
For lookout stations	Desk set, W. E. No. 1300–N. Desk stand, W. E. No. 1020–S. C., with No. 143–W receiver.
For lookout towers	Do.
For reconnaissance crews, improvement crews, etc.	Forest Service portable telephone No. 1375–A. Ground rod, Forest Service portable No. 313–B. Line connector, Forest Service portable No. 311–B. Dry battery for Forest Service portable telephone, Columbia O. V. No. 3 or ever-ready tungsten, No. 703.
Installing instruments:	
Lightning arrestors	Protector W. E. No. 60–E. Protector blocks, W. E. No. 20 and No. 21. Protector micas No. 10 for repairing No. 60–E protector.
Fastening wires (outside)	No. 4½ porcelain knob, to be held by No. 16 or No. 14, 3-inch flathead wood screw.
Fastening wires (inside)	¼-inch Blake insulated staple.
Insulation through walls	¼-inch flexible conduit (circular loom), for single and twisted pair inside wire. Use ⅜-inch conduit for 2 outside wires.
Fuses	Line fuse No. 47–A.
Ground	Ground rod, W. E. No. 52108, galvanized.
For connecting ground and metallic lines:	
Relaying device	Repeating coil, W. E. No. 47–A.
For breaking up line units:	
Connecting two lines	One single-pole, double-throw Bryant knife switch, W. E. No. 1454. One single-pole, single-throw Bryant knife switch, W. E. No. 1436. One extension bell, W. E. No. 127–F.
Connecting three lines	Three single-pole, double-throw Bryant knife switches, W. E. No. 1454. One single-pole, single-throw Bryant knife switch, W. E. No. 1436. Two extension bells, W. E. No. 127–F. (One of these extension bells should be equipped with cow gong.)
Connecting four lines	Four single-pole, double-throw Bryant knife switches; W. E. No. 1454. One single-pole, single-throw Bryant knife switch, W. E. No. 1436. Three extension bells, W. E. No. 127–F. (Two of these extension bells should be equipped with cow gongs and sleigh gongs, respectively.
Connecting more than four lines	Unit switchboard, W. E. No. 1800. Whenever this equipment is necessary, the needs should be fully stated to the district forester, so that the order may be placed properly.

Location of Telephone System.

Each ranger district presents certain communication needs with a degree of uniformity so constant that the standard or average needs of the typical ranger district are not difficult to state. The typical district has a man in charge located at a fixed point in the fire season. To this central intelligence comes all the information on every fire in order that it may act intelligently on each. At a fixed point in this district, presumably, is a specialized agency detecting fires. In it also are one or more men whose function is to corral each fire that starts, each located at a fixed point. There are also moving about in the district one or more men whose function it is to prevent fires from starting. In addition there are from one to a hundred points at which fire-fighting labor can be obtained. The district ranger must also transmit and receive information to the supervisor in charge of the Forest.

The problem is to lay out a system of telephone lines with the least mileage that will connect each point, fixed and moving, with the unit which can call it into action in the shortest time. To attack it, on an inch-to-the-mile map of the Forest or of the ranger district plat, first, the control divisions. Then plat each point occupied by a unit of the protection force (platting lines for the moving points). From each draw a straight dotted line to the location of the unit that can call it into action anywhere within the control division in the shortest time. Then, in a solid line, trace the closest practicable route for a telephone line to each dotted line, or group of dotted lines. A comparison of the result with a map of the existing telephone lines in the district may offer valuable suggestions for betterment of the system, and a comparison of such maps of adjoining ranger districts may show the need of closer correlation of district system.

Phone Construction.

There are two possible ways of reaching and maintaining a standard in telephone line construction: By having all work done under the immediate supervision of a single specialist or by issuing the standards in simple written form to all rangers who engage in the work and checking the result by inspection from the supervisor's office. The first is the surest and the second the cheapest. A practical difficulty in the way of the first is the urgent need, often, of building two or more lines in widely separated localities at the same time. The second method will be used in District 5 and all tree-line construction, replacement and repair will follow closely the standards laid down in the Telephone Construction Manual, by R. P. Adams. Each supervisor will see that every Forest officer in charge of telephone-line construction work has with him *on the ground* while work is in progress a copy of this circular.

In the rare instances where pole lines are necessary, the construction standards will be those laid down in the pamphlet entitled, "Instructions for the building and maintenance of telephone lines on the National Forests."

Supervisors will be responsible for the adherence to these standards, and all lines hereafter built or replaced will be subject to inspection from the district office.

Operators.

No matter how perfect the mechanics of line construction and instrument installation may be, the whole efficiency of the protection telephone system (measured in acres burned over) is absolutely dependent upon there being present at the right point some member of the organization who can take or send a message at any time a fire may occur. And this is at any minute in any hour of the twenty-four every day of the fire season. The ideal organization, then, will provide absolutely continuous service at every phone at a fixed point. How near an approach to this can be obtained economically is a matter requiring careful study by the supervisor in each division of his Forest organization. It is obvious that where two or more Forest lines on which we are dependent for fire information center in a commercial exchange, night operators must be provided, if not by the company, then by the Service.

The following books are listed for reference:

Subject.	Name.	Author.
Development and Technology of Telephone Instruments.	American Telephone Practice.....	Kempster B. Miller.
Make-up and Use of Instruments...	Practical Telephone and Guide to Telephone Exchange.	T. S. Baldwin.
Telephone Equipment and Its Uses.	Current Catalogues................	Western Electric Co., San Francisco.
Do...........................	A. B. C. of the Telephone.........	James E. Homans.
Technical and Scientific Treatise on Construction and Installation.	Telephone Construction Methods and Cost.	Clarence Mayer.
Wire, its Weight, Breaking Strength, and Resistance.	Handbook........................	Phillips Insulated Wire Co., Pawtucket, R. I.
Trouble Shooter's Guide...........	Hyde's Telephone Troubles and How to Find Them.	W. H. Hyde.
Primer of Telephone Construction..	How to Build Rural Telephone Lines.	Western Electric Co.
Manual of Standard Practice.......	Electrical Instruments and Telephones, U. S. Signal Corps.	Brig. Gen. A. W. Greely.

For the purposes of informing the control organization of the start and location of a fire, lookout stations must be equipped to convey considerable detailed information. Flags, cones, squares, circles, or any other devices hoisted to a masthead can not convey this information in sufficient detail unless given the meaning of letters with which words may be spelled. And this, of course, takes too much time.

Heliograph.

Such signals—much more easily seen, much more readily understood, and far quicker—can be transmitted by heliograph. In regions of class A fire danger not yet supplied with a telephone system, lookout stations will be equipped with heliograph instruments, as will also the nearest (or most logical) visible point which now has telephone connections, the aim being to make heliograph communication a forerunner of telephone communication and connected with it. On no lookout will it replace the telephone or be permanently substituted for it.

Still other communication needs may be met with the heliograph as soon as an instrument of portable size and weight is developed. By its use the patrol may be told when to connect with a phone and the forest fireman may get word to the district ranger just as soon as he finds out that he is not going to be able to control a fire by himself. Both should be equipped to take the least possible time to do this.

Because there is little or no available literature on the heliograph, it is necessary to consider here at some length the instrument, the methods of operating it, and its adaptation to protection uses. The following standard methods and the uses to which the heliograph system may be put were determined after two seasons' careful experiment in the field:

The basis of the heliograph instrument is a mirror with which to reflect the sun's rays steadily in a given direction and a mechanically controlled shutter by means of which the sun's reflection may be alternately exposed and obscured, so as to transmit a series of long and short flashes. The field heliograph equipment consists of—

- A sole-leather case, containing—
  - Two mirrors inclosed in a wooden box.
  - One sighting rod.
  - One shutter.
- A smaller leather pouch sliding by two loops upon the strap of the larger case, containing—
  - One mirror bar.
- A skeleton leather case, containing—
  - Two tripods (fitting one within the other).

In preparing for communication the instruments are removed from the cases and the tripods are set up close to each other. On the top of one is screwed the shutter and on the top of the other the mirror bar. If the sun is in front of the operator as he

faces the receiving station, only one mirror is necessary and this is fastened at the end of the mirror bar and the sighting rod at the other. If the sun is at the back of the operator as he faces the receiving station, it is necessary to fasten both mirrors to the mirror bar so as to secure a double reflection of the sun.

By means of the sighting rod and the tangent screws, the instrument is sighted upon a receiving station and the mirror so adjusted that the reflected ray is projected directly toward the station. Due to the apparent movement of the sun, *the mirror must be constantly adjusted.* This is particularly important in view of the fact that the circle of illumination created by the mirror has a diameter which increases only 50 feet for every mile of distance from the mirror. For example: If the receiving station were 6 miles distant, the space at that place within which the flash could be seen would be a circle only 300 feet in diameter.

The shutter is placed directly in the path of the reflected ray. Flashes are transmitted by opening and closing the shutter by means of a key.

Several different makes of heliograph instruments have been used. Experience has shown that the instruments manufactured by Kueffel & Esser and the Eugene Dietzen Co. are the best. The outfit complete for one station (either make) costs $55.

The only feasible code for heliograph communication is the Myer code used as a standard by the Signal Corps of the Army. The Morse code is primarily designed for audible signaling and is not well adapted to heliograph communication. The alphabet and conventional signals of the Myer code are based on a combination of ones and twos as follows:

Heliograph Code.

A	22	J	1122	S	212
B	2112	K	2121	T	2
C	121	L	221	U	112
D	222	M	1221	V	1222
E	12	N	11	W	1121
F	2221	O	21	X	2122
G	2211	P	1212	Y	111
H	122	Q	1211	Z	2222
I	1	R	211	Question	1112

ABBREVIATIONS.

A	After.	N	Not.	Ur	Your.
B	Before.	R	Are.	W	Word.
C	Can.	T	The.	Wi	With.
H	Have.	U	You.	Y	Yes.

CONVENTIONAL SIGNALS.

End of a word: 3.
End of a sentence: 33.
End of a message: 333.
Acknowledgment, or "I understand": 22 22 3.
Repeat last word: 121 121 33.
Repeat last message: 121 121 121 333.
Wait a moment: 1111 3.
Signal faster: 2212 3.
Cease signaling: 22 22 22 333.

This information should be always handy to the operator, as should also be the following detailed instructions:

Instructions to Operators.

The first position is to turn a steady flash on the receiving station. The signals are made by long and short flashes.

"1" is represented by a short flash.

"2" by two shorter flashes in quick succession.

"3" by a long steady flash.

It is of the utmost importance that uniformity in mechanical movement of the shutter be cultivated, as lack of rhythm in the signals of the sender entails unnecessary and vexatious concentration of attention upon the receiver.

The flashes should be sharp and clear cut. For a "3" dwell somewhat upon the exposure, with a tendency to lengthen rather than shorten the period of duration.

To call a station.—Send a rapid succession of flashes until acknowledged. Each station will then turn on a steady flash and adjust. When the adjustment is satisfactory to the called station it will cut off its flash and the calling station will proceed with its message.

Adjustment.—If the receiver sees that the sender's mirror needs adjustment, he will turn on a steady flash until answered by a steady flash. When the adjustment is satisfactory the receiver will cut off his flash and the sender will resume his message.

To break or stop the signals from the sending station.—Make a rapid succession of short flashes without pause until sender stops sending.

To start the sending station after breaking.—Turn on a long flash and he will commence at the beginning of last word.

To acknowledge receipt of a message.—Signal 22 22 3 followed by the name of the receiver.

If the sender discovers that he has made an error he should make a rapid succession of short flashes after which he begins with the word in which the error occurred.

To lessen liability of error, numerals which occur in the body of a message must be spelled out in full.

A record of the time of receipt and transmission of every official message must be kept. Sample heliograph messages (heliograms) are attached. One of these should be made out for every official message sent or received.

In receiving messages nothing should be taken for granted and nothing considered as seen until it has been positively and clearly in view. Do not anticipate what will follow from signals already given. Watch the communicating station until the last signals are made and be very certain that the signal for the end of a message has been given.

Attempts to attract the attention of a station to be successful must be persistent. They should never be abandoned until every device has been exhausted.

It has been proven by experience that the average mountain man selected for lookout service is quite capable of learning and becoming proficient in the use of the heliograph. *The first step in installing this system on a Forest should be to secure the services of an experienced instructor to train the new men.* This should not be difficult, since several of the Forests are making use of this system of communication and, on request of the district office, can detail a man for instructions. In heliograph work practice is absolutely essential to fast and intelligible signaling. A common fault is the failure to keep the mirror in perfect adjustment while operating. This fault is extremely annoying to the receiving station and must be eliminated. The actual spelling out words is not the difficult part; the trouble comes in in the ends of words, ends of sentences, ends of messages, getting started, failure to observe the conventional methods of calling, breaking signals, starting again, acknowledgment of messages, etc. It is only through constant drilling, as in the case of telegraph operating, that the heliograph man learns these tricks of the trade.

All messages transmitted or received should be recorded by both sending and receiving operators on blanks which will be known as heliograms. Sample heliograms are shown on figure 12.

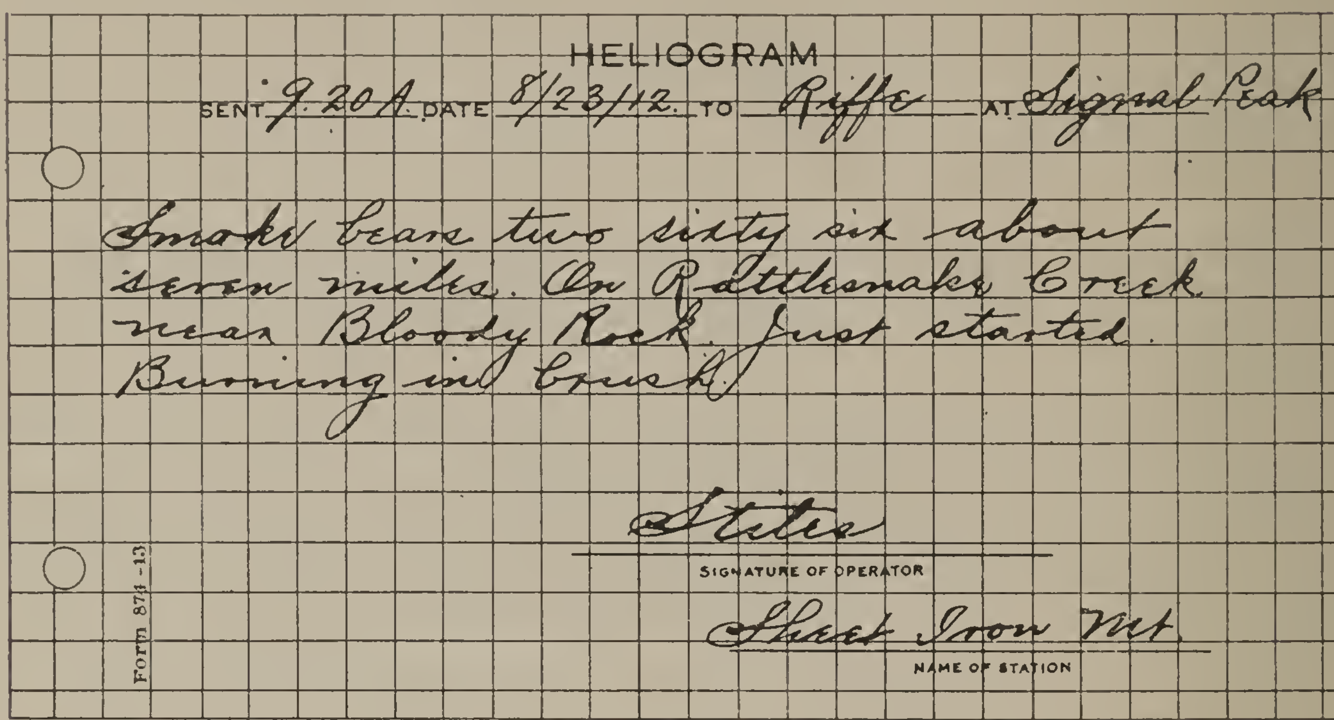
The average speed attained by the best Forest Service operators has been found to be about four words a minute. The average fire message need not exceed 20 words, so it will be seen that after the discovery of a fire an expert heliograph man can get the news to his receiving station in five minutes. Twice this length of time should be a safe figure for an ordinary operator.

The range over which heliograph signaling may be affected under favorable atmospheric conditions, such as usually exist in the high mountain regions in the early part of summer, is almost unlimited, except, of course, by curvature of the earth. Actual communication has been carried on at a distance of 50 miles. Messages may be transmitted through a slight haze, but when the atmosphere becomes thick with smoke it is impossible. The great disadvantage of the heliograph system is the impossibility of communicating on cloudy days. The instrument is useless under these circumstances.

Uses of Heliograph.

In addition to primary lookout work, the heliograph can be made to fill the need of communication in three distinct situations:

1. Fireman to lookout.
2. Patrolman to lookout.
3. Officer in charge of fire to lookout.



HELIOGRAM

SENT 9.20A. DATE 8/23/12. TO Riffe AT Signal Peak

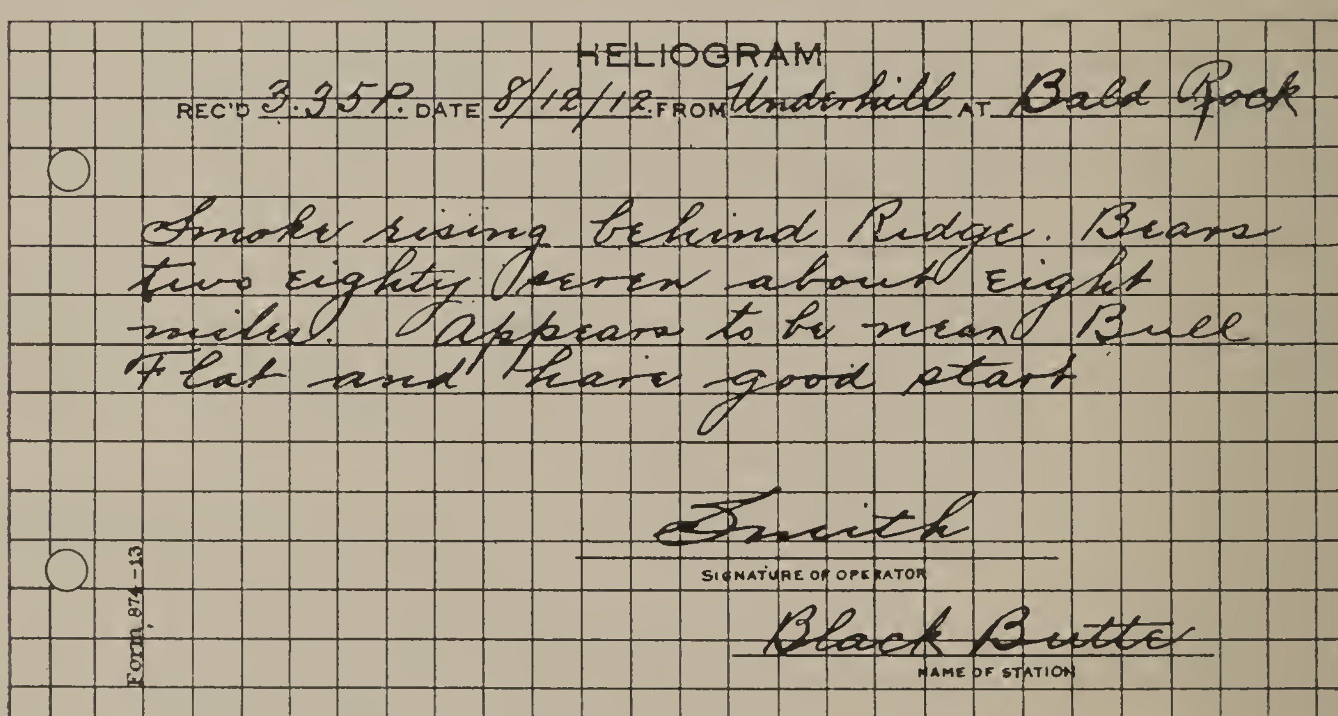
Smoke bears two sixty six about seven miles. On Rattlesnake Creek near Bloody Rock. Just started. Burning in brush.

Stiles
SIGNATURE OF OPERATOR

Sheet Iron Mt.
NAME OF STATION

Form 874-13

Sample Heliogram Form for Transmission of Message



HELIOGRAM

REC'D 3.35P. DATE 8/12/12. FROM Underhill AT Bald Rock

Smoke rising behind Ridge. Bears two eighty seven about eight miles. Appears to be near Bull Flat and have good start.

Smith
SIGNATURE OF OPERATOR

Black Butte
NAME OF STATION

Form 874-13

Sample Heliogram Form for Receipt of Message

FIG. 12.—Samples of heliogram forms for transmission and receipt of messages.

In the case of No. 1: When a Forest fireman is without telephone service, but is so located that there are within his field of vision one or more lookout stations connected by phone with fire-control forces, the lookout stations can be made heliograph central stations and the fireman stations made heliograph substations. An application of this system is shown by figure 13.

In the case of No. 2: There are many occasions for communication between the man riding through the Forest and other units of the control force. If the patrolman is not close to a telephone line, the heliograph will serve his purpose when he has a pack

horse. If he is familiar with his division, a patrolman can go immediately to the nearest high point or ridge from which a lookout station is visible, set up his heliograph instrument, and get into communication with the lookout man. The message can then be transmitted to the proper officers. The need for this will occur when the patrolman sights a fire, or finds one he can not handle alone, when regular reporting in is required of patrolmen, or when the patrolman has noted anything of fire protection importance, such as actions af incendiaries, movement of campers, changes of

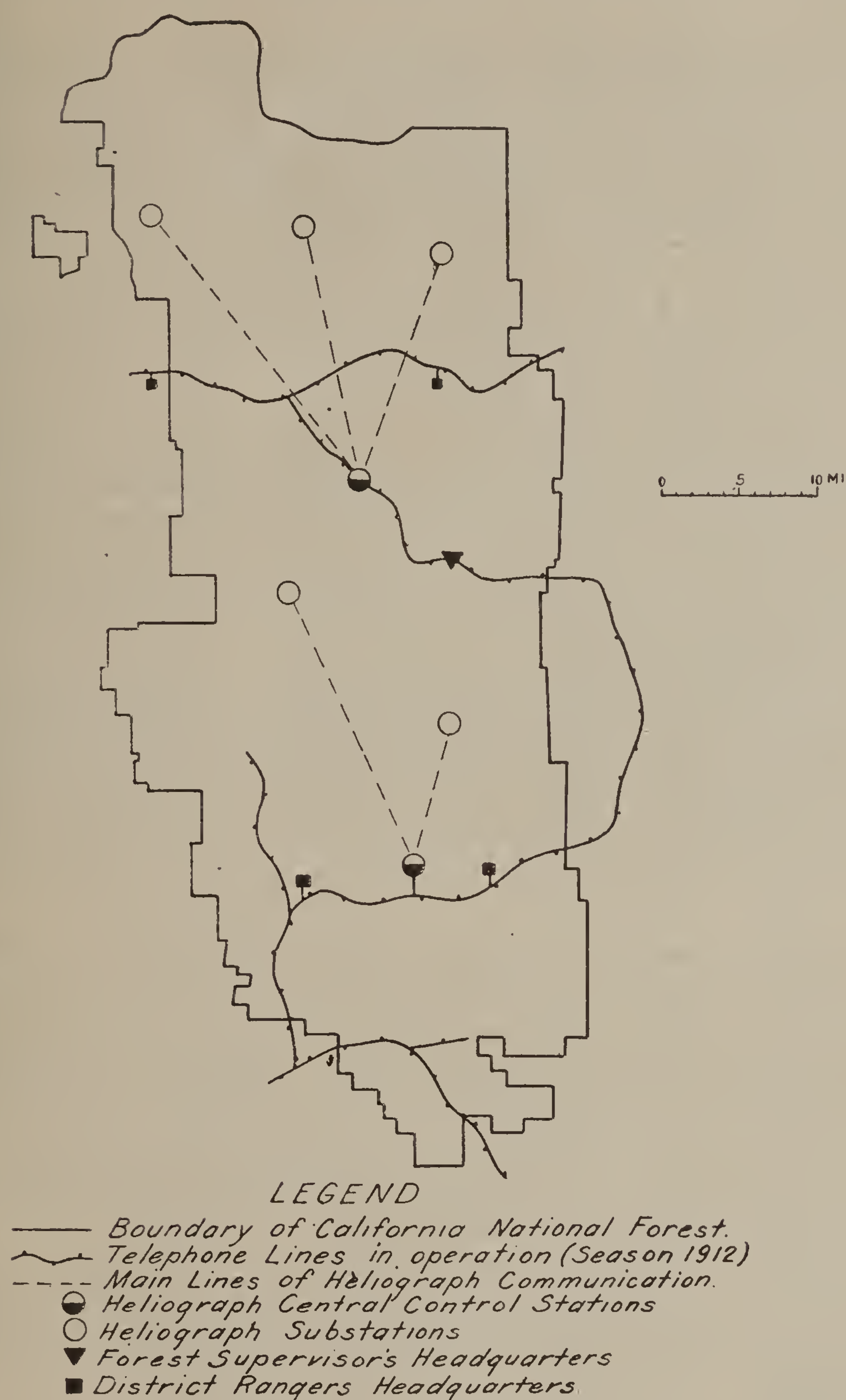


FIG. 13.—Map of California National Forest showing heliograph system. Season 1912.

atmospheric or meteoric conditions. The standard heliograph instrument is an awkward article to pack and an impossible article to carry on a saddle horse, but investigations are now in progress to develop a much lighter and smaller instrument.

In the case of No. 3: If an instrument is taken to a fire, communication can be established with outside forces in most instances. If a Forest is well covered by lookouts, an operator can usually, by going a short distance from the fire, get into communication with one of them. Because of the obstructions offered by the smoke, the wind-

ward side of the fire must be selected for the set-up. This system may be used for reporting progress of fire, ordering tools, provisions, men, etc., and communicating the numerous things necessary at such a time.

CHAPTER XII.

TOOLS AND SUPPLIES.

Purpose of Tools.

Before we discuss fire-fighting tools, we must state clearly the work which should be done to stop a fire from spreading and to extinguish it. To stop its spread along the ground entails laying bare a strip of mineral soil around the fire across which it will not burn, but often some preparatory work is necessary to permit the inflammable ground cover to be reached. The first work to be done, then, is the removal of brush, reproduction, slash, or logs. The second is the constructon of a fireproof strip. This entails the moving of from one to four feet of dead material—needles, leaves, twigs and small limbs, and growing plants—grass, weeds, bear clover, squaw carpet, or dwarf manzanita. The dead material, being loose, is much easier to remove than the plants, which are anchored by roots.

Fire, being helpful in widening this strip, it is therefore necessary to scatter burning litter or trash along it, and then beat out the flame along the strip of bare mineral soil.

To prevent the spread of fire above the ground it is necessary to remove brush or snags from which fire is likely to jump. It also entails the removal of low-hanging, moss-covered limbs, the breaking up of clumps of brush or young growth, and the removal of dry standing sticks.

To extinguish isolated fire spots within the burned-over area earth may be used, burying burning logs, or putting it on burning stumps and pitch holes in tree trunks not over six feet high; or water must be used for burning spots higher above ground.

Here, then, are things which may have to be done in any fire fight. They can not be done with the bare hands. Tools and utensils are needed which will scrape ground, cut both solid wood and limber brush, loosen and carry dirt, carry fire, and carry and throw water.

What are the shapes, weights, and sizes of the tools that will do these things most effectively with the least expenditure of human effort? Can a tool be developed that will perform with equal effectiveness a combination of two or more of these functions? How difficult is it to remove each type of material? These and other similar questions must be answered before a scientifically correct tool for any one or all of these purposes can be developed, and systematic study and experiment are necessary to formulate the questions properly and to answer them correctly. Such studies and experiments will be carried on by special assignment.

In the meantime we can select for general use from the tools designed primarily for other purposes (loosening, moving, and leveling earth, etc.) those which the experience of the field has shown to be the most effective for fire-fighting purposes.

Standard Tool List.

A tool list follows, which shows for each tool the work it is to perform, and why it is selected.

For the present these will be obtained locally, but as soon as arrangements can be made with manufacturers and dealers, a supplemental list will be issued showing for each tool, where it can be obtained, its code number for ordering by wire, its unit price at a stated f. o. b. point, and the firm which can supply it cheapest.

TABLE XII.—*Standard tool list, District 5.*

Tool.	Purpose.	Description.	Reason for standardization.
Auger	For boring powder holes in snags	Double twist, old style, 2-inch, 30 inches in length, ordinary handle; 2-inch ship auger with screw starter, 30 inches in length, loop eye welded on handle; 2-inch ship auger with screw starter, 36 inches in length, with loop eye welded on handle.	All 3 tools are needed at different depths of the hole bored. Diameter of bore gives best results with powder. Stick may be cut for handle. Order without handles for ease in packing.
Ax	Cutting logs, trees, reproduction, limbs	$3\frac{1}{2}$-pound double-bitted Puget Sound falling ax; 36-inch straight white-oak helve, Phoenix brand, Young pattern.	Extra blade for rough work. Blade narrow, permitting deep cut. Blade thin, easily sharpened with file. Twice as effective as pole ax.
Small saddle or belt ax	To supplement other tool on a one-man fire. Patrolman's ax.	$2\frac{1}{2}$-pound boy's ax with pole-ax handle	See "Purpose."
Brush hook	For brush or reproduction removal where necessary. Need restricted. In most cases may be replaced by combination of brush knife and hand ax.	Collins, medium weight, with standard 36-inch handle.	Has most curve, thereby conserving edge and making upstroke easier. Attachment to helve more secure.
Brush knife	For cutting brush, reproduction, and small limbs.	"Slosson brush knife," with sheath; single-handed slashing knife, recurved blade.	Light weight ($1\frac{3}{4}$ pounds). Used in combination with hand ax furnishes complete cutting outfit. Easily carried.
Hoe	Scraping duff, needles, bear clover, squaw carpet, or grass.	7-inch oval-eye planters' hoe, blade sharpened on outside; handles (separate), 60 inches long, $1\frac{1}{4}$ inches in diameter.	Takedown and easily carried. Oval eye prevents turning on handle. Best height from edge to back and most effective angle of blade to handle. Strongest hoe obtainable.
Hatchet	For brushing out lines, etc. Easily portable	$1\frac{1}{2}$-pound huntsman's ax with 18-inch pole ax-shaped handle.	Something still lighter and more easily carried. A one-hand cutting tool to supplement the two-hand axes.
Plow	For plowing furrow to serve as back-fire line. A furrow below a side hill fire furnishes a gutter to catch rolling brands. Plows should be more widely used.	10-inch side hill plow, P. O. or Oliver make. Should be furnished with wrought-iron clevis and beam reinforced with strap iron or extra heavy oak beam.	Selected after three months try out on fire line construction work. Hangs up less than other types. Light enough to pull out by hand and much superior to disk types of soil cutters.
Saw	Falling snags and trees. Cutting logs out of fire line.	Simmons falling pattern, 6-foot saw	Thin, narrow, and cheap for the quality.
Rake	To move light dead ground cover (needles, leaves) and to string fire along a back-fire line.	3-pound rake, 16 inches wide, having 10 teeth $\frac{3}{4}$-inch long and 1.6 inches apart; a 12-inch iron shank and handle set in solid socket. (No rake of exactly these specifications is now made. Until it is, use the nearest thing to it.)	A heavy rake quickly tires the user. Needles quickly clog short teeth set close together. An inserted shank and ferrule (the ordinary trade rake make-up) burns out in stringing fire.
Shovel	Scraping line, cutting light roots, carrying earth to extinguish fire, stringing fire and beating it out.	For timber type, No. 2 pressed steel, round-pointed, miner's pattern shovel.	Round cutting edges necessary to loosen earth.
Water bag and water buckets.	To carry water to men on line, and for putting out burning spots inside fire line.	5-gallon South African water bags and canvas buckets, both on requisition from property clerk.	Water can be packed in bags as easily as in specialized containers. Bags allow distribution in small amounts where needed. Buckets used with hand pump.
Hand pump	Putting out fires inside the line and holding back fire; also front fire in grass.	Single forester, double-action hand pump operating in canvas water bucket, held in place by foot piece.	Easily packed and strongly made. Throws a solid stream $\frac{1}{2}$ inch in diameter at nozzle 30 to 40 feet. Has been successfully tried out.

Combination Tools.

Field officers of the district have expended considerable thought and shown much ingenuity in devising special combination tools. The most promising of these to date are the McLeod tool, developed by Ranger Malcolm McLeod, of the Sierra Forest, and the Gott tool, developed by Ranger William Gott, of the Klamath Forest.

The McLeod tool consists of a three-pronged iron shank ending in a socket which receives the removable handle. The prong ends are threaded and receive either a hoe blade, a rake blade, or both at once, held in place by hand-set wing nuts.

The Gott tool consists of a three-section handle made of piping and screwed together for use. Its lower end is threaded to fit a blade which set at one angle to the handle is a shovel, at another a hoe. A rake head is also provided.

The combination take-down tools developed so far are deficient in rigidity and balance. Possibly these defects can be remedied when a tool receives sufficient field test, is passed upon favorably by the standardization committee, and is submitted to a manufacturer for a working model.

Every encouragement to invention should be offered. Tool designs submitted to the district office will, upon request and if they appear to have any merit at all, be made up and the model returned to the inventor for field trial. If a favorable report on this field trial is forthcoming, the tool will be returned to the district office for further test and experiment by the standardization committee. If passed by the committee, arrangements for their manufacture will be made. Successful tools will be named after their inventors, and the development of such tools will count strongly on an officer's efficiency record.

Caches.

The need of tool and grub caches has been demonstrated. Many types are in use. The best type is the upright box, because tool handles do not warp when hung up and do warp when they are not hung; cutting edges keep in better shape when tools are hung up; and the upright box is more noticeable and easier to get at.

Ranger Albert E. Redstone, of the Sequoia Forest, has developed what appears to be the best type in use so far. (Fig. 14.) The following is the amount of lumber needed and the estimated cost of building this type of cache:

125 feet lumber, at $17 per M	$2.12
Nails, shakes (20 shakes)	.25
2 pairs strap hinges	.50
1 quart paint	.50
Labor, including painting	2.00
Total	5.37

Further study and test will be made, however, before it is definitely adopted as a district standard.

Cache Equipment.

The complement of tools for a cache will be determined by the number of men it is desired to equip from that point, and the type of cover in the area served by the cache. Tacked on the inside of each cache should be a list of its normal contents. However, there is a certain equipment in addition to the tools that should be placed in every cache, regardless of the type of cover. This list is as follows:

6 or more 8-inch mill files.
2 canvas water buckets.
3 or more 2½-gallon water bags or canteens (or both).
1 No. 1 Balwin camp lamp.
1 can of carbide.

Such equipment as plows, chains, harnesses, augers, powder, and pumps, are essentially emergency equipment, and should be placed in centrally located points from which additional supplies will be sent in case the fire assumes larger proportions. In

cases where it is desired to combine the tool and food caches, the amount and kind of foods placed in the cache will correspond to the amount of nonperishable foods listed in the "One-man-one-day" order, Table XII, for the maximum number of men that the tool cache will equip. The supplies should be for a period of 24 hours, or until

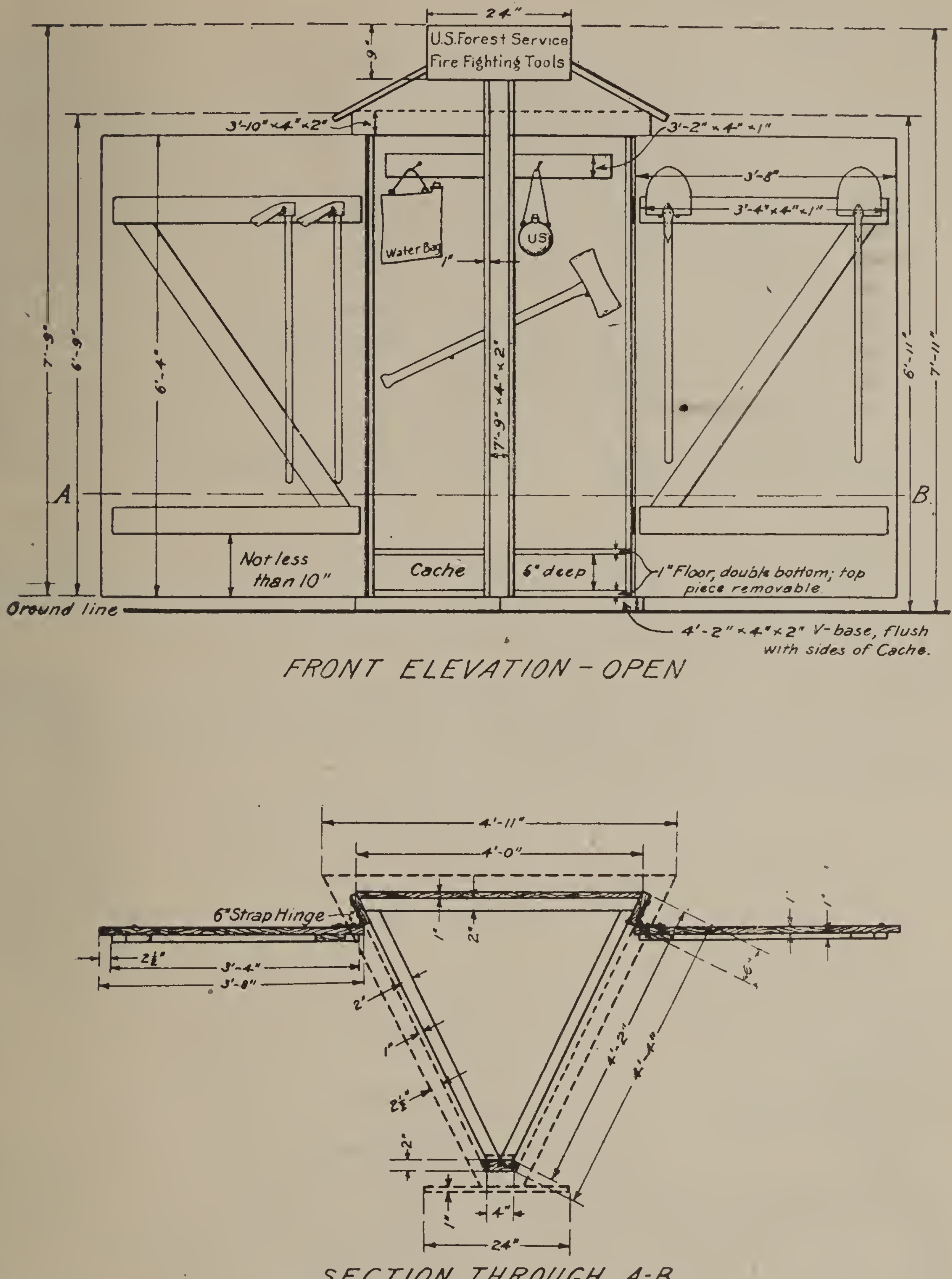


FIG. 14.—Redstone tool and supply cache.

such time as a regular supply can be delivered on the ground from the nearest base. Hardtack should be substituted in this table for bread or crackers.

Food supplies are needed in the Forest for subsisted officers in the regular control organization and for feeding the fighters on any fire that is not held by that organization. Food cached an indefinite time before it is needed must necessarily be nonperishable.

Supplies not cached in advance and used for subsisted protection men or fire fighters must constitute a well-balanced ration, must be palatable and possess high nutritive value, and must be in packages easily transported with rough handling. They must be in such shape that they may be easily and quickly prepared for consumption under adverse conditions.

Packed Kyacks.

Even where food caches are not used, kyacks packed in advance with the standard for 10 men (with the exception of perishable goods) will often save 10 minutes to an hour where time is most valuable. Such a pack should be maintained at every ranger station. No paper packages should be used under any circumstances. Every article not in cans should be placed in seed sacks (on requisition from the property clerk) and the name of the food stenciled on the outside of the sack.

Thirst is the great hardship on the fire line. Yet if a man under violent exertion in the heat is given all the water he wants he weakens rapidly. Water containing molasses and ginger, or oat meal-water, or the juice of canned tomatoes will give a man the needed amount of moisture with the least weakening effect, because he will not drink so much. Chewing tobacco or gum may be furnished to fire fighters; these stimulate a flow of saliva and decrease the craving for water. Brandy (rather than whisky) should be kept in the fire camp and used sparingly as a restorative in cases of exhaustion or heat prostration. No liquor of any kind will be allowed on the fighting line.

Supply Lists.

Table XIII gives supply lists from which, by interpolation, may be figured the food necessary for any number of men for one, two, three, four, or five days. Table XIV gives the cook outfits necessary for 5 to 30 men, and their weights.

Bedding.

Bedding is essential to the proper working condition of the men in a fire fight of any duration. One quilt per man should be provided, and from four to six can be packed on top of each pack animal load sent to the fire.

TABLE XIII.—*Fire-crew ration list, 10 men.*

Article.	Unit.	Days. 1	2	3	4	5
Meat alone:						
Fresh meat	Pounds	20	40	60	80	100
Canned or cured meat	do	12	24	36	44	52
Meat combined:						
Fresh meat	do	10	20	30	40	50
Canned or cured meat	do	6	12	18	22	26
Bread, crackers, or flour:						
Bread	Pound loaves	9	18	27	36	45
Crackers	Pounds	6	12	18	24	30
Flour	do	8	16	24	32	40
Baking powder (if above amount of flour is used)	do	½	½	1	1	1
Lard	do	1	2	3	4	5
Sugar	do	4	8	12	16	20
Sirup	Quarts	1	1	2	2	3
Coffee, ground	Pounds	2	4	6	8	10
Tea	do	½	1	1	1½	1½
Milk, canned	10-cent size cans	3	6	9	12	15
Butter	Pounds	1	2	3	4	5
Fruits, dried or canned:						
Dried	do	2	2	3	3	3
Canned	Quarts	3	6	9	12	15
Rice	Pounds	2	4	6	8	10
Beans	do	3	6	9	12	15
Potatoes	do	10	20	30	40	50
Onions	do	1	2	3	4	5
Tomatoes, canned	Large can	3	6	9	12	15
Macaroni	Pounds	1	2	3	4	5
Cheese (American)	do	2	4	6	8	10

TABLE XIII.—*Fire-crew ration list, 10 men*—Continued.

Article.	Unit.	Days.				
		1	2	3	4	5
Erbwurst	do	½	½	1	1	1½
Pickles	Quarts	½	1	1	1½	1½
Salt	Pounds	1	1	1	2	2
Pepper	Ounces	2	2	4	4	4
Dish towels (cheesecloth)	Yards	3	3	5	5	5
Twine	Balls	1	1	1	1	1
Hand towels	Number	3	3	3	3	
Candles	do	3	6	9	12	15
Soap (hand, Sapolio, and laundry)	Bars	2	3	4	4	4
Matches	Boxes	1	2	3	3	4
Paper bags		12	24	36	48	60
Total weights		138	229	369	485	587

TABLE XIV.—*Fire-crew camp equipment.*

Utensils.	Number of men.					
	5	10	15	20	25	30
Knives, table	7	18	24	30	36	36
Forks, table	7	18	24	30	36	36
Teaspoons	7	18	24	30	36	36
Spoons, stirring	1	2	2	3	3	3
Plates	7	18	24	30	36	36
Cups	7	18	24	30	36	36
Milk pans (dish ups)	1	4	4	4	4	4
Dish pans	1	1	1	2	2	2
Fry pans	[1] 3	4	4	5	5	5
Stew kettles (½-gallon)	2	3	3	3	4	4
Meat forks	1	1	1	1	1	1
Canvas water pails (2-gallon)	1	3	3	3	3	3
Butcher knives	2	2	2	2	2	2
Stewpans, assorted	2	3	3	3	3	3
Can opener	1	2	3	4	5	5
1-gallon coffee pot	1					
2-gallon coffee pot		1	2	2	3	3
Dutch ovens	1	1	2	3	4	4
Meat saw			1	1	1	1
4-gallon stew kettle			1	1	1	1
2-gallon stew kettle			1	1	1	1
Lanterns	1	2	3	4	5	5
Weights	40	80	120	160	200	240

[1] Small.

CHAPTER XIII.

REDUCTION OF HAZARD.

Definition.

Used in connection with fire protection, the term "reduction of hazard" means the removal of inflammable material from the forest at any time other than when a forest fire is actually burning. The object is to decrease the amount of fuel that a fire might feed upon. Because of the expense entailed, it is confined to areas which are subjected to high risk, to classes of material which are particularly inflammable or dangerous, or to areas which it is particularly desired to safeguard.

Slash Burning.

Private timberland owners and operating lumber companies in California are now using two methods of hazard reduction—slash burning and light burning. In certain pine operations in Northern California the slash resulting from logging is fired in the late summer or the fall, and an effort made to consume as much of it as possible without permitting the fire to spread into the uncut timber.

Light Burning.

Light burning, although less prevalent, is still practiced by at least one owner of large timber holdings, and is publicly advocated by several California lumbermen as a prevention measure against fire loss. The method consists first in preparatory work of filling up the fire scars in the butts of standing trees with stones and earth, and raking the litter from around each tree. Then, after the first rains in the fall, the forest floor is fired broadcast in order to consume all inflammable débris and leave nothing for a fire to feed upon in the heat of the dry season. As practiced, the preparatory work costs about 35 cents per acre and the burning about 15 cents.

Objections to Burning.

The Forest Service in California can use neither of these methods without greatly lessening the value of the properties it is set to manage. It can not permit the areas cut over under timber-sale contracts to be burned broadcast, because to do so would destroy young growth, the saplings, small trees, and seed trees, which form the basis of the second crop.

For exactly the same reason—safeguarding the young growth—the Forest Service can not use light burning as a fire protection measure, even if it could be done at reasonable cost. No method of light burning has yet been devised which in the typical sugar and valley pine stands of California insures the safety of the immature timber and the young growth.

Correct Methods.

The Forest Service in California is now using five other methods of hazard reduction—the construction of fire lines, the falling of snags, the systematic disposal of débris resulting from timber cutting, specialized stock grazing, and the construction of specially prepared camp grounds.

Fire Lines.

The type of fire line depends first on the purpose it is designed to effect, and, second, on the character of the cover through which it runs. Three types have so far been developed—the timber fire line, the slash fire line, and the brush fire line.

The purpose of the timber fire lines is to reduce the cost of and increase the protection to lands capable of producing merchantable timber. Without fire lines, timberland is protected and production is assured by getting men to each fire as quickly as possible and constructing a line around it. If productive timberland lies directly adjacent to a highly inflammable area, past experience has shown that many fires will start in the inflammable area and run into the timber. A study of past suppression costs may show that it is cheaper to spend less money in fighting individual fires outside the timberland and invest the saving in preparing a fighting base along its edge.

The same study will probably show that a reasonable degree of protection can be secured at less cost by fighting each fire in the inflammable area than by building a fire line so wide and so clean that it will automatically hold the maximum fire that might come up against it.

A fire line is justified:

1. If the area to be protected has a real present or productive value which will be materially decreased if fires run over it; and
2. If this area lies adjacent to an inflammable area where many fires start.
3. If the advance preparation of a fire-fighting base between the two areas insures less shrinkage in present values or less loss in production at a cost the same or less than that of suppressing each fire in the inflammable area without such a base; or
4. If the decrease in shrinkage of present values or the decrease in lost production is greater than the excess cost of the fire line over fire suppression.

The forest officer considering the construction of a fire line must weigh the sum of the increased dependability of his protection system, the decreased cost of his control organization, and the decreased cost of fighting fires against the sum of the cost to construct the fire line and the cost to maintain it.

Keeping in mind that the present stage of development of fire protection in California points clearly to a fighting base rather than an automatic break, the type of construc-

tion should conform to the use to which the control organization will put it. As a point from which to set and hold a back fire, the line should consist of a comparatively narrow cleared strip from the front of which is removed such material as would make for abnormal heat intensity were a fire actually burning up to the back-fire line. Back of the line such material as would easily catch and spread fire should be removed. These two strips in which the hazard is reduced are called the front and back protection strips, and it goes without saying that, for a distance at least equal to their lengths, all snags should be removed from both sides of the back-fire line.

Location of Fire Lines.

When a fire line is to be built and its type determined, it is most essential to fix upon its exact location on the ground before doing any construction work. The line should always be located by an officer with a very intimate knowledge of the country. He must also have had wide experience in the actual suppression of fires in the types through which the line is to run. A man with this knowledge and experience can, with every rod of the line, presuppose the occurrence of a fire and fix the location at the most advantageous point to combat it. Where the line will run will be determined by the following factors:

1. Shortest distance, considering 2 and 5.
2. Ease or difficulty of construction, considering 5.
3. Suppression cost, using the line as a base.
4. Cost of maintenance.
5. Back-firing safety.
6. Cost of protection organization, with the line built.

These factors properly weighed will finally be adjusted to give the shortest line at the least expense in construction, maintenance, and patrol, with the greatest factor of safety.

Something over 158 miles of this type of line were built along the line of contact of the timber and brush types of the Sierra, Sequoia, and Kern Forests in the winter of 1914. Accurate cost and other data are available for 116.5 miles, and as similar work will undoubtedly be undertaken elsewhere the lessons learned through experience on this pioneer attempt are explained in some detail.

Organization of Crews.

A crew unit of 10 men, a cook, and a foreman were easily and efficiently handled. These men were experienced woodsmen, with one or two farmers apt at handling horses. The foreman was an experienced fire fighter and of demonstrated ability in the handling of men. He was responsible for the day's work of the crew, the cost-keeping system, the ordering of supplies, and minor deviations in plan of line construction and location made necessary by unforeseen contingencies.

Tools and Equipment.

The following tools and equipment were used:

1 Dimo grit emery wheel.
3 No. 1 saddle axes.
2 No. 2 pole axes.
12 No. $3\frac{1}{4}$ D. B. falling axes (handled).
3 extra 36-inch ax handles.
1 7-inch Atkins falling saw (4 cutters to the raker).
1 pair falling saw handles.
1 No. 7 sledge.
2 No. 6 falling wedges.
1 set saw filing tools (wrought iron).
2 No. 2 shovels.
1 10-inch side hill plow, Oliver pattern.
1 extra share for plow.
1 extra beam for plow.
1 wrought-iron $\frac{3}{4}$-inch clevis.
72 8-inch mill files for saws and axes.
36 6-inch mill files for saws and axes.
12 4-inch mill files for augers.

1 pair stretchers (chain $\frac{3}{8}$) $1\frac{1}{4}$-inch pipe spreaders.
4 brush hooks.
2 1-quart canteens for coal oil.
1 pack saddle, Kyacks.
6 knapsacks.
2 14 by 16 tents ($\frac{1}{2}$ pitch roofs, 16 ounce duck).
1 14 by 16 fly.
1 14 by 16 tent floor.
7 excelsior mattresses or sleeping pockets.
3 pair small pliers (Bernard).
12 No. 112 double-sided carborundum stones.
1 singletree.
1 30-foot $\frac{3}{8}$ chain.
100 feet $\frac{1}{2}$-inch hemp rope.
1 shoe repair outfit.
1 medicine chest (loaded).
1 small air-tight heating stove, 6 lengths pipe and 2 elbows.
15 pounds nails, 8d, 10d, and 20d.
1 gallon coal oil can.
2 2-inch double twist 30-inch ship auger.
1 2-inch single twist 30-inch ship auger (with screw) oval eye.
1 2-inch single twist 36-inch ship auger (with screw) oval eye.
3 lanterns with reflectors.
2 horses and harness.
4 horses and two wagons (if transportation by road).

COOK OUTFIT—12 MEN.

1 Sietz stove, with 6 lengths pipe and 2 elbows.
16 plates.
16 cups.
1 2-gallon coffeepot.
1 1-gallon teapot.
16 knives.
16 forks.
16 teaspoons.
2 pepper shakers, large.
2 fry pans.
2 roast forks.
2 large cooking spoons.
2 4-gallon dish pans.
6 large pie tins.
2 pint sirup pitchers.
2 quart milk pitchers.
2 sugar bowls.
16 tablespoons.
2 soup ladles.
1 hot-cake turner.
1 5-gallon kettle.
6 pots, from $\frac{1}{2}$ to 2 gallons.
12 separate bread pans.
1 large roast pan.
1 medium roast pan.
1 6-quart pudding pan.
4 1-gallon milk pans.
16 soup bowls.
2 salt shakers, large.
2 butcher knives.
1 meat saw.
1 knife, steel.
4 canvas buckets.
1 5-gallon bucket.
5 yards dark oilcloth.
1 washtub.
1 washboard.
14 folding camp chairs.

5 folding camp tables.
12 sugar sacks.
2 wash basins.

Personal equipment was limited to 60 pounds, including bed. The medicine chest was stocked by a competent physician and contained remedies for colds, headaches, indigestion, cramps, toothache, sprains, and injuries.

Winter work was necessary to utilize the services of statutory-roll men, to insure softness of the ground, and to make burning a safe adjunct to line construction. Provision against storms necessarily increased the bulk of the equipment.

Transportation.

It was found that the problem of transportation should receive a great deal of attention during the preliminary work incident to the location of the line. Camps from 6 to 10 miles apart, depending on the type of country, should be located before work starts, so that supplies can be sent directly to the camping places, making it unnecessary to carry a great bulk along with the crew. If roads are at all accessible to the line, the problem is greatly simplified, as the plow team or teams can be used to move with the equipment. In inaccessible points it was necessary to u e pack animals, but if the bulk of supplies were distributed in camps ahead, together with feed, six horses were sufficient to move the necessary supplies and equipment to the next camp in one day and prevent the work from being delayed, the crew working on the line toward the next camp. Of course, camps were located in the center of a stretch of unfinished line, so work could be done both ways from camp.

Crews.

The crew was divided into three units:

Powder or saw crew	2 men
Plow crew	2 men
Ax crew	6 men

Powder or Saw Crew.

The powder or saw crew was equipped with three augers and handles, one 2-pound pole ax, one 4-inch mill file, one empty coal-oil can, powder, caps, fuse, pack horse, saddle, and kyacks. The men were experienced in the handling of powder. When saws were needed the men were equipped with one 7-foot falling saw (four cutters to the raker), falling-saw handles, two falling wedges, one No. 7 sledge, 1-quart canteen for coal oil, one No. 2¼-inch falling ax, one carborundum stone. The men should be of the same height in order to get the best results.

Plow Crew.

Both members of the plow crew understood the handling of horses and plows. The man who drove the horses saw to their care in camp. They were equipped with plow, monkey wrench, saddle ax, and one 8-inch file.

Ax Crew.

The ax crew consisted of the balance of the men, usually six, but the foreman spent most of the time with them. They were equipped with falling axes, carborundum stones, and files.

All crews were furnished with knapsacks for carrying lunch and with water bags. It was often necessary to increase the snag crews when one 2-man crew could keep up with the ax crew.

Method of Clearing Lines.

The ax crew brushed out the line to a width determined by the foreman, and depending upon the fire danger. Of necessity this width was sufficient to enable the plow crew to work to advantage. The ax crew also removed such inflammable material in both the front and back protection strips as would seriously endanger the control

of the back fire. All brush was piled in open places in front or behind the back-fire line in compact piles for burning later. Small snags up to 10 inches in diameter were disposed of by the axmen after the line was cleared. The plow crew followed with a furrow on each edge of the brushed out strip as close to the brush as possible. Unless climatic conditions allow of its burning at once, the strip between will be burned at the time the cut brush is disposed of. The plow crew was followed where necessary by one or two men with shovels to complete the line in the few spots where rock or topography made the use of a plow impracticable. The snag crew operated on both sides of the fire line, removing all snags that would in any way endanger the control of a fire, without regard to distance.

In all cases where a snag was dropped close to the line the branches were lopped and piled along the trunk and burned.

The disposal of snags by the use of powder proved to be an effective method. It is described in detail under "Snag Disposal," page 85.

Costs.

The following table shows the total cost in money and the labor cost in man-days of constructing 116.5 miles of timber fire line. The total cost includes the lost time on account of storms, delays, and the transportation of statutory-roll rangers to and from their headquarters to the Forest on which the work was performed. The total cost of the equipment is charged off against this work, while, as a matter of fact, only the depreciation is properly chargeable. By using the actual working time, as shown by man-days per mile of line constructed, the labor cost can be determined for any price of labor. Very material reductions can undoubtedly be made with further experience and careful preliminary planning.

TABLE XV.—*Fire line construction costs.*

SUBDIVISION OF WORK.

	Cook.	Wrangler.	No work.	Moving.	Timber.	Oak.	Chaparral.	Roads.	Total.
Man-days	106	32	349	201	175	39	166	130	1,198

TOTAL COSTS.

	Timber.	Oak.	Chaparral.	Roads and trails.	Total.
Per cent of total	34	8	32	26	
Transportations	$365.39	$86.00	$343.78	$279.38	$1,074.55
Subsistance, including salary of cooks	447.97	105.39	421.59	342.54	1,317.49
Salaries [1]	1,132.72	266.52	1,066.07	866.18	3,331.49
Powder	36.34	8.54	34.18	27.77	106.83
Tools	80.57	18.95	75.83	61.62	236.97
Equipment	105.86	24.91	99.64	80.95	311.36
	2,168.85	510.31	2,041.09	1,658.44	6,378.69

[1] Includes "No work."

TABLE XV.—*Fire line construction costs*—Continued.

LABOR COSTS.

Cost in man-days for the actual working time and total and unit cost.

	Timber.	Oak.	Chaparral.	Roads or trails.	Total.
Miles constructed	32	4.2	15.8	64.5	116.5
Man-days	290	66	276	217	849
Man-days per mile	9	16	17.5	3.4	11.4
Total cost	$2,168.85	$510.31	$2,041.09	$1,658.44	$6,378.69
Cost per mile	$67.77	$121.50	$129.12	$25.86	$54.84

Cost per meal, with ranger cook	$0.375
Cost per meal, with professional cook	.285

Slash Fire Lines.

Slash fire lines are designed to prevent the spread of fires in slash left after unregulated cutting on private land onto adjacent National Forest areas. To put them on the actual boundary usually requires their construction through heavy slash and the absolute cleaning of a comparatively wide line. Considerable ax work is necessary, and the débris is piled and burned in the line. The ground is raked clean toward the slash. Costs of slash fire lines actually constructed have run as follows:

	Per mile.	Per square rod.	Per acre.
8-foot line, medium heavy slash	$31.00	$0.19	$31.00
10-foot line, medium heavy slash	30.75	.16	25.60
16-foot line, heavy slash	80.00	.25	40.00
20-foot line, heavy slash	45.00	.11½	18.50

Brush Fire Lines.

A great many miles of brush fire lines have been built on the watershed protection Forests of southern California. These follow the main and lateral ridges and are designed to confine any fire that starts to the topographic unit in which it is burning and also to furnish a base from which to back-fire and a road on which to move men. These lines average 50 feet in width, and the stumps of the chaparral species are grubbed. Grubbing, while it increases the initial cost, lowers the maintenance cost, as ungrubbed stumps sprout rapidly. Brush lines built in the District cost as follows:

	Per mile.	Per square rod.	Per acre.
50-foot line, heavy brush	$250.00	$0.25	$40.00
32-foot line, heavy brush	240.00	.37½	60.00
10-foot line, heavy brush	100.00	.38	60.00

After several years of experience, the construction of wide fire lines has been abandoned in the protection Forests of southern California. They are not automatic fire breaks in any except light winds. Their greatest usefulness is a line from which to set and hold a back fire and a route on which to move men quickly to vantage points on the steep brushy slopes. These two purposes are both served equally well by the narrower line which can be constructed at less than half the cost per mile. Lines averaging 10 feet in width, therefore, have been adopted as the standard for this region.

Snag Disposal.

A ground fire, reaching a dry tree stub or snag, runs up it and burns for a long time in the top. Burning brands, even in a moderate wind, often blow over a quarter of a mile from the top of a burning snag, setting new fires where they strike the ground. Standing snags, therefore, are one of the greatest fire menaces in the forest. Many a fire completely surrounded by a fire-proof line breaks out again because a snag some

distance inside the burned area has thrown fire across the line. The danger of a snag increases with its height, and pine snags are often 200 feet high. Snag removal is, therefore, an important part of hazard reduction, and is carried on in connection with fire-line building, with cutting operations, with insect-control work, or as an operation by itself in the virgin forest.

Three months' actual experience in snag disposal by both saw and powder in the fire-line work in which upward of 2,000 snags were felled has put this work beyond the experimental stage and has developed methods that can be accepted as standard.

Tools.

Tools for a two-man powder crew are as follows:

1 double-twist old-style 2-inch auger, 30 inches in length, ordinary handle—for use in starting holes in unsound wood;

1 ship auger, with screw starter, 30 inches in length, 2 inches in diameter; and 1 of the same pattern 36 inches in length, 2 inches in diameter.

A loop eye should be welded on the head of these augers, oval in shape, and an oval-shaped handle made with crank attachment. The handle should taper slightly, to permit sliding the crank up or down and making short or long strokes for soft or hard wood. To let the handle out for a full stroke makes the boring much easier for hard timber. (Fig. 15.) A 2½-pound poleax was found to be best for this work, as it is light, handy, and easily carried on a pack horse.

These tools, with the addition of a tamping stick made of wood and a sharp pocket knife for splitting the powder, are all the tools necessary for shooting snags.

Holes.

To insure felling the snag, the holes should be of sufficient depth to allow the charge of powder to lie as nearly as possible in the center of the cross-section of the sound wood. This equalizes the resistance on all sides. In a tree 36 inches in diameter, for example, a hole should be bored two-thirds of the distance through the tree so that the bulk of the charge would lie directly in the center of the tree. In trees up to 40 inches in diameter one hole can contain enough powder to fell the tree. In trees between 40 and 48 inches in diameter two holes are necessary, bored from opposite sides at the points of the greatest diameter of the tree and connected in the center. On trees from 48 to 60 inches in diameter three holes should be bored and connected in the center of the tree, dividing the tree into three equal segments. Larger trees may be felled with powder by boring four holes at right angles and connecting them in the center.

Powder.

Experiments made with 20, 30, and 40 per cent powder demonstrate 20 per cent powder to be the most efficient and best to handle. Moreover, it is less liable to freeze in higher altitudes than powder containing a higher per cent of nitroglycerin. The size of the cartridges (1½-inches) is most satisfactory.

For trees 40 inches in diameter and under, one stick of 1½-inch 20 per cent powder to each foot of solid wood was found to be the charge necessary to fell the tree. For trees of a diameter requiring two or more holes, one and one-half sticks of the same grade of powder to the foot of solid wood was used. This rule was successfully applied on trees up to 72 inches in diameter, where three holes are used.

Burning Trees.

Whenever a snag is dry or pitchy enough to burn, it is invariably cheaper and fully as effective to place a light charge of powder in the tree in such manner that it will shatter and splinter the butt to such an extent that it is easily set on fire and burned down. The fire sometimes burns the entire tree after it has fallen. When this method is used with large trees it is sometimes necessary to shoot two charges in opposite sides of the tree, thereby making a hole through the tree and creating a draft.

The proper charge of powder for this method of removal is two-thirds of the amount used to shoot down a tree of the same diameter.

Transportation of Tools.

All the tools and sufficient powder for a day's work of a two-man crew can be carried on one pack horse.

Thawing of Powder.

The advice issued in the circulars of powder manufacturing companies regarding the thawing of powder is very comprehensive and should be carefully followed.

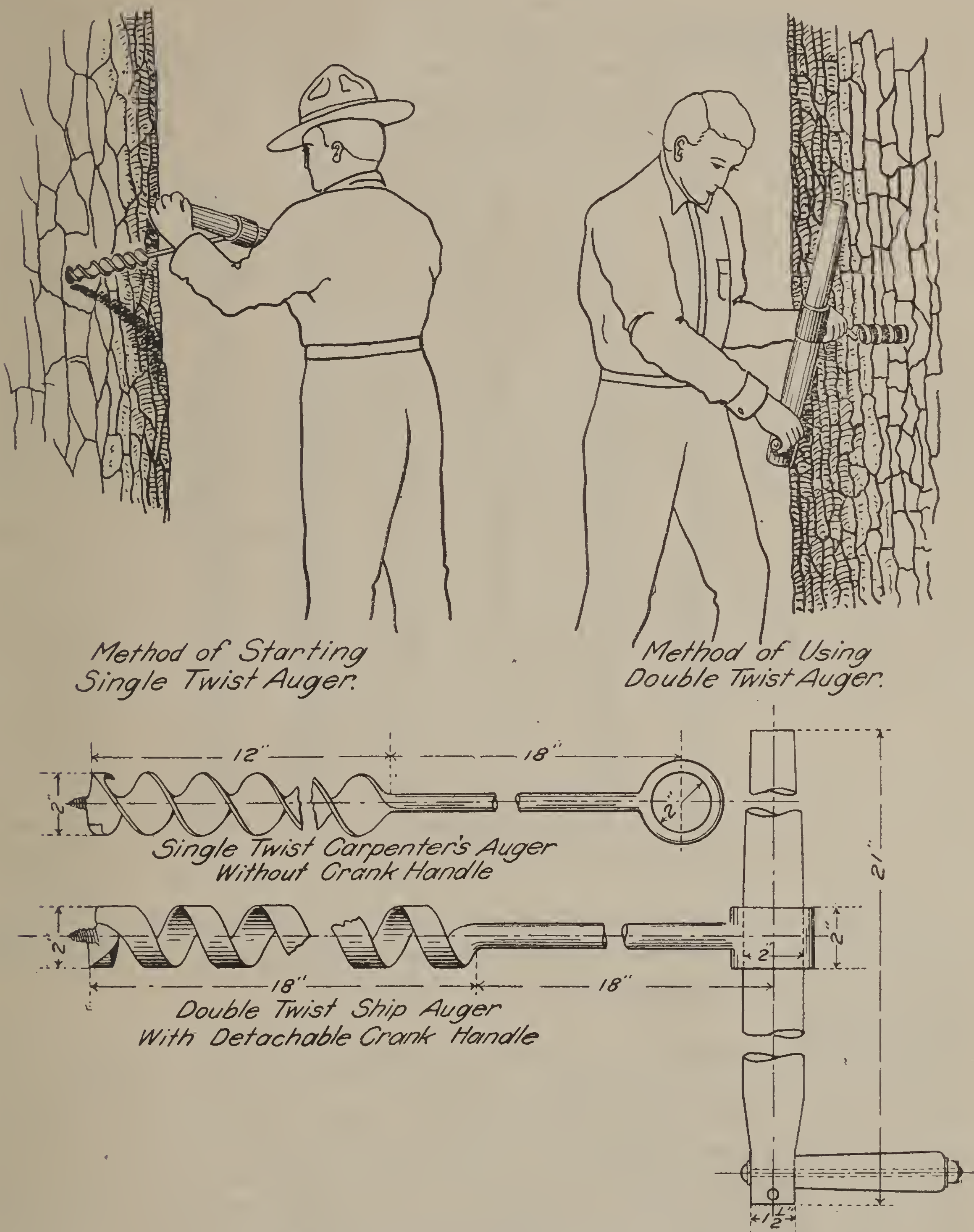


FIG. 15.—Tree boring equipment.

Care must be taken to keep the can containing the powder free of clear nitroglycerin. In unusually cold weather the powder can be thawed in camp before leaving, and when on the trail the portable thawer advocated by the powder companies can be easily carried on the pack horse.

Undercutting with a charge of powder will sometimes fell the tree in a desired direction, if it is absolutely plumb; but if the tree leans it will invariably fall the way it leans.

The costs of snag disposal are shown in the following table:

TABLE No. XVI.—*Snag disposal, showing time, amount of powder, and costs by both methods of disposal.*

[Based on average diameter of trees put down in day's work of 5 actual working hours, travel excluded.]

Diameter of snag.	Falling time.		Powder.	Cost per inch.	
	Saw.	Powder.	Amount.	Saw.	Powder.
	Minutes.	*Minutes.*	*Pounds.*	*Cents.*	*Cents.*
6	3	....	....	0.0080	....
8	5	....	....	.0090	....
10	6	....	....	.0100	....
12	7	8	0.3	.0110	0.0190
14	8	10	.5	.0120	.0180
16	10	12	.7	.0130	.0170
18	12	14	.9	.0135	.0165
20	14	15	1	.0145	.0160
22	15	16	1.2	.0150	.0155
24	18	17	1.3	.0160	.0155
26	20	17	1.4	.0165	.0155
28	23	18	1.6	.0175	.0160
30	25	19	1.7	.0180	.0165
32	28	19	1.8	.0185	.0165
34	32	20	1.9	.0190	.0170
36	35	21	2.1	.0200	.0175
38	38	22	2.2	.0205	.0175
40	42	24	2.3	.0215	.0180
42	46	25	2.6	.0225	.0180
44	50	26	2.7	.0235	.0185
46	56	28	2.9	.0250	.0185
48	61	29	3	.0260	.0190
50	67	30	3.2	.0265	.0195
52	71	32	3.4	.0275	.0195
54	75	33	3.5	.0280	.0195
56	79	35	3.6	.0285	.0200
58	82	36	3.8	.0290	.0200
60	87	37	3.9	.0295	.0200
62	91	38	4	.0295	.0200
64	94	40	4.1	.0300	.0200
66	98	41	4.2	.0305	.0200
68	101	42	4.3	.0305	.0200
70	104	44	4.3	.0305	.0205
72	107	45	4.4	.0310	.0205
74	110	47	4.5	.0315	.0210
76	112	48	4.6	.0320	.0215
78	....	49	4.6	....	.0220
80	....	51	4.7	....	.0225

From this table it will be seen that for snags up to 22 inches in diameter, it is cheaper in both time and money (cost of powder included) to fell them with a saw; for snags over that size, shooting them down is more economical.

Brush Disposal.

Inflammable débris—limbs and branches—resulting from cutting operations under Forest Service timber sale contracts, are disposed of by piling and burning. The tops are lopped clear of limbs by the swampers. After the logs have been removed from the woods the resulting débris or brush is piled compactly, the piles averaging 5 to 8 feet in diameter and 3 to 5 feet in height, particular care being taken to locate each pile so that it can later be burned with the minimum damage to young growth or to timber left standing. The piling is done by men in the pay of the operator under the direct supervision of a Forest officer. After the first rains in the fall the brush piles are burned either by rangers and guards or by men employed by the operator under close supervision of Forest officers. A coal-oil torch may be used for this work, and fire-fighting tools must be at hand in the event of fire spreading. Nice judgment is necessary to pick a time when all the conditions are right to make brush burning safe. One extra day of dry weather may make all the difference between a safe burning proposition and an exceedingly dangerous one.

The cost of this method of brush disposal varies with the density of the stand and the severity of the cut. The following figures give fair average costs for typical mixed conifer stands in California. Allowance is made for this cost in appraising the stumpage value of National Forest timber for sale.

TABLE XVII.

Original stand per acre.	Per cent cut.	Brush piling.		Brush burning.	
		Per acre.	Per M feet.	Per acre.	Per M feet.
Feet.					
15,000	66	$2.47	$0.25	$0.30	$0.03
20,000	70	3.50	.25	.42	.03
25,000	70	4.37	.25	.52	.03
25,000	80	5.00	.25	.60	.03
30,000	75	5.62	.25	.67	.03
30,000	80	6.00	.25	.72	.03
35,000	75	6.56	.25	.79	.03

All brush cut in the course of improvement work is disposed of in a similar manner. The result of definitely adopting and consistently adhering to this policy is that the National Forests are slowly but surely undergoing a general course of cleaning up which, even in the comparatively short time they have been under management, has disposed of an ernormous amount of inflammable débris.

Effect of Grazing on Fires.

A special study was undertaken in 1912 of the relation of grazing of livestock in the National Forests to the protection of the Forests from fire. This study demonstrated conclusively that grazing lessens the number and intensity of fires and renders them less difficult to control. Grazing does this by the annual removal of inflammable growth, by the breaking up of down limbs, brush, and litter, and by bringing a large number of auxiliary fire fighters into the Forests.

Even though lightning may not strike twice in the same place, it is very likely to strike many times in the same locality. In other words, there are distinct belts or zones where lightning fires can be expected to occur. Platting the location of each lightning fire for the last six years will outline the boundaries of these zones. They generally lie at comparatively high altitudes and in a country where the chief resource is the forage crop. Each supervisor should plat these zones and study the utilization of the range within them. If not fully stocked with cattle or sheep (preferably sheep), arrangements should be made to stock them. A forcible illustration of this effect of grazing occurred on a California National Forest in 1911, when 21 of the season's total of 68 fires were caused by lightning. In one instance 7 lightning fires were started, 5 in a region grazed by sheep and 2 outside of the great area. The 5 fires on the sheep range went out before being reached by the control organization, while the 2 outside burned until reached and controlled by the Forest officers.

Grazing hastens the breaking up and decay of down timber, limbs, and litter by bringing them into closer contact with the mineral soil and moisture. The effect is to expose a greater total surface of the débris to the disintegrating elements. The regular stock driveways should, just as far as is practicable, be laid out to conform to the main fire-line plan of the Forest. The most logical place for a driveway is along a ridge. This is generally the most logical place for a fire line also. Wherever possible the two should be made to coincide. Old burns, slashings, and other fire traps may be rendered less of a menace by overgrazing them with sheep.

In the next revision of the fire plan each supervisor, recognizing the vital connection between fire protection and grazing, will determine where the latter can serve to reduce hazard.

Prepared Camps.

On every route in the mountains popular with summer campers there are certain spots which by reason of their distance from the starting point or their monopoly of the essentials of a night's camp—wood, water, and feed—are natural camp grounds. From the point of view of the forester it is much safer to have this traveling fire risk concentrated each night in as few camps as possible. This concentration can be encouraged by rendering the logical camping sites along each popular route as attractive as possible. At such sites meadows may be reserved from stock grazing and fenced (with smooth wire) for the campers' horses and pack animals. Or, if no green feed is available, racks and boxes for feeding hay and grain may be constructed. Rough tables and benches may be built of poles and tent poles and pegs cut and left ready for use. A serviceable stone fireplace should be built and all inflammable material raked clean 10 feet on all sides of it. The brush and down limbs on the whole camp ground should be cut, piled, and burned, and around the whole, inclosing ample ground, should be cleaned a 3-foot fire line.

On a tree near the fireplace should be tacked a bulletin board bearing all signs governing the use of the camp, its name, the direction and distance to the next camping places, rules for the sanitation of the grounds, the Six Rules, the location of the nearest ranger and telephone, such folders and maps as it is desired to give away, and a camper's register. A shovel should be hung under the bulletin board. Over it should be a sign: "Please extinguish your camp fire with water. Then use this shovel to cover it with damp earth before you leave in the morning. Return it to this nail, so the next man can extinguish his fire, too."

The primary object of these camp grounds is to induce transients to camp at places where the danger of their fire escaping has been reduced to a minimum. But to accomplish this object it may be necessary to construct for public use an exceedingly attractive camp ground. The limit of their usefulness is reached when preparation of additional sites would not give increased fire protection—not before.

CHAPTER XIV.

EMERGENCIES.

Emergency Defined.

A forest fire emergency may be defined as an abnormal combination of climatic conditions and physical factors greatly intensifying the fire danger. An emergency is not a bad fire or a series of bad fires. Such conflagrations are the *result* of emergency conditions, and it is the cause that we must define, learn to recognize the moment it comes into existence, and take immediate steps to counteract. To act only when we see the results of an emergency will always be too late.

Normal Conditions.

This study may be approached by stating normal summer fire conditions and then determining the degree of deviation from each condition which, when it occurs, constitutes an emergency. Each supervisor will make a study of his past weather and fire records and list for his own Forest the normal fire season conditions. Using the statement which follows as a guide, he will then define and list his Forest emergency conditions. These will be corrected from time to time as more concrete knowledge becomes available, and as rapidly as possible the process will be worked out for ranger districts.

Precipitation.

The winter precipitation in California, while not in itself an indicator of fire conditions during the coming summer, may furnish a guide for a forecast as to whether or not an emergency is likely to occur. Throughout California the normal average rainfall varies from 9 to 60 inches. It can easily be ascertained for a given locality by applying to the nearest office of the United States Weather Bureau. The amount of rainfall

during November, December, January, and February will not materially affect fire conditions during the following summer; but to insure a normal fire season there must be a normal precipitation during March, April, May, June, September, and October. Any precipitation less than normal in these months in a given locality should put us on our guard for an emergency during the summer in that locality.

Wind.

The velocity of the normal summer wind is approximately 8 miles an hour for the west slope of the Sierras, the Coast Range, and southern California; for the east side it is about 17 miles an hour. The occurrence of a wind exceeding the normal velocity for the locality by 4 miles an hour and lasting over 24 hours may be taken as an emergency condition. A "Santa Ana" or strong northeast wind in southern California always indicates an emergency, as does also a cyclonic storm of any severity. In the latter case, an emergency will immediately be declared over the whole region within the periphery of the whirl.

Heat.

Normally hot weather may be expected from June 1 to October 15, with an average maximum temperature in the mountains of 80° for June, 90° for July, 90° for August, and 80° for September. Hot periods of four or five days' duration, when the maximum temperature stays 5° to 10° above these averages, may be taken as normalities of the average summer season. Where, however, there occur six or more successive days when the maximum temperature exceeds the monthly normal by 8° or more, an emergency may be said to exist. Abnormally long hot periods in May or June, or in the last half of September or the first half of October (if it has not yet rained), are much more dangerous than similar conditions in July or August.

Atmospheric Conditions.

Normal atmospheric conditions in California are as follows:

June: Clear. No interference with lookout service.

July: Fairly clear. Hazy during the hot periods. Little interference with lookout service before July 25.

August: Very hazy. Difficulty will be experienced by lookout service in accurate location of fires, especially during the hot periods.

September: Same as August, until the first rain, after which it is entirely clear.

An emergency will be considered to exist whenever, by reason of atmospheric interference with vision, a lookout station is put out of commission. Such emergency will cover the whole territory left without detection service.

Increase in Fires.

Each Forest and each ranger district on each Forest has a normal number of fires which occur each season. This number may be arrived at in the same way by which normal precipitation is arrived at—the average over a period of years. The normal number of fires for the district is 798. An epidemic of fires which increases the normal for the locality *for any ten-day period* by 50 per cent or more should be considered an emergency.

The occurrence of any one of the abnormalities described constitutes an emergency fire situation, and obviously the occurrence of any two or more of them in combination creates a still more serious emergency. The Forest protection plans should be revised to define emergency conditions for each ranger district and to provide exactly what action shall be taken by each unit of the Forest organization in emergencies of different degrees of seriousness.

Recognizing an Emergency.

With the definition worked out the man on the ground must be made responsible for the recognition of the existence of emergency conditions. If it is a patrolman or lookout, he should notify the district ranger, who should confirm his judgment and notify the supervisor. In every instance the supervisor will immediately notify

the district forester by wire when an emergency exists on his Forest, where it is, what constitutes it, and what he proposes to do about it. He will also keep the district forester informed of the situation by nightly telegraphic reports.

Action to be Taken.

The supervisor will notify the proper officer to take immediate charge of the situation—presumably the district ranger, if the emergency is local. This officer will tighten up the control organization, seeing to it that every man is at his proper station and is informed of the possible demands that may be made upon him. He will also see to it that all equipment and facilities—tools, telephone lines, or means of transportation—are in first-class working order. The supervisor will notify other rangers in charge of districts not threatened to hold themselves in readiness to reenforce from their men the control organization on the threatened district. He will also notify all men on any line of work other than protection—administrative, reconnaissance, improvement, or investigative—to hold themselves in readiness for orders to go on protection work.

If an emergency affects a whole forest, the supervisor will personally assume charge. After all available men on the forest pay roll are on protection duty, this force may be augmented by hiring emergency patrolmen, lookouts, and forest firemen. This, of course, entails previous authority from the district forester for the expenditure of emergency funds. If local labor resources are exhausted and outside help is needed for control—not fire fighting—the district forester, on request, will endeavor to secure it by immediate temporary transfer of rangers from other Forests not threatened.

In the meantime, and before the need for them arises, the supervisor should complete arrangements for the organization and mobilization of the volunteer fire-fighting forces of his Forest. He should arrange to obtain, at a moment's notice, conveyances to move a large force of men to any point on his Forest. He should learn by wire how many men are available for immediate forwarding at labor agencies in the nearest towns. If it comes to a case of fire fighting and there seems any likelihood of the situation getting beyond control of the Forest force, the district forester should be wired to dispatch outside help from other Forests. Each supervisor's office will be furnished each spring with a table showing what reenforcements can be expected on short notice from each Forest. A request for reenforcements should state the supervisor's preference of where they are to come from; but in order that a second threatened point may not be uncovered, Forest reenforcements will move only on order from the district forester.

The emergency reenforcement plan will show, for each Forest, what other Forests can send assistance to it, how many rangers or fire fighters can be sent, where they will assemble, how they will be transported, the points at which and the number of hours in which they can be delivered, and notes on the character of labor which will be sent. This plan will be revised annually.

District Office.

Upon declaration of a fire emergency, the district forester will take charge in the district office and remain where he can best communicate with the supervisor, the Forester, and labor supply, and transportation centers. If, in his judgment, it is necessary administrative work will stop and every able-bodied man will be assigned to protection duty.

The district forester will handle emergency finances. Telegraphic requests for funds from the supervisors will be in terms of the amount needed per day for emergency control work.

Any assistant district forester or subordinate officer may be dispatched by the district forester to the scene of the emergency to act under the general direction of the supervisor. The supervisor will remain in charge. Only when he has shown himself

clearly incompetent to handle the situation will a supervisor be supplanted by order from the district forester.

Whenever requested by the supervisor, competent district officers will be sent to designated points to act under his direction as purchasing, forwarding, and labor agents. Whenever necessary, a qualified disbursing agent with the necessary funds to his credit will be sent to the scene to pay fire-fighting bills on the ground.

It must be borne in mind that in a serious fire emergency lives and property are at stake, and the whole Forest Service organization has no duty other than fire protection until conditions are restored to normal. Absolute discipline is necessary. The man in charge, presumably the supervisor, will handle the situation, and his statement of conditions and of his needs will be taken without question.

Help from the Army.

When a situation occurs so serious as to be beyond the resources of the Forest Service—and not before—the district forester, on receipt of a telegraphic report and request from the officer in charge on the ground, will endeavor to secure the help of the United States Army. Such a request should state how many men are needed, the probable length of time, the tools with which they should be equipped, and the railroad point at which they should detrain.

Transportation upon their arrival at that point should be provided by the supervisor, who should report personally to the ranking officer in charge of the troops, and act thereafter as his technical aid in fire-fighting work. He should demonstrate what is to be done by the troops, where it is to be done, and how it is to be done. Two forest officers acting in a similar capacity should be detailed to each company commander. Under no circumstances will any forest officer give orders or commands to any troops unless specifically detailed in charge of a body of soldiers by a commissioned officer.

The financing of troops on forest-fire work will be arranged between the district forester and the Department Commander, and the supervisor notified.

APPENDIX.

Summary fire report, 1908, 1909, 1910, 1911, 1912, 1913.

Items.	1908 No.	1908 Per ct.	1909 No.	1909 Per ct.	1910 No.	1910 Per ct.	1911 No.	1911 Per ct.	1912 No.	1912 Per ct.	1913 No.	1913 Per ct.
Class:												
A. ¼ acre or under	142	63	161	58	126	50	294	52	372	77	912	83
B. 10 acres or under	194		118		101		124		254		441	
C. Over 10 acres	192	37	197	42	326	50	379	48	186	23	275	17
Total	528		476		553		797		812		1,628	
Class A's		27		34		23		35		46		56
Location or origin:												
(1) On National Forest land	....		288		319		476		405		1,046	
(2) On private land inside	....		99		149		201		257		356	
(3) Outside boundaries	....		89		85		117		150		226	
(4) Causes of fire:												
Railroad	12		22		11		24		93		64	
Lightning	158		84		110		282		206		804	
Incendiary	13		17		59		92		71		133	
Brush burning	17		37		29		38		42		78	
Campers	108		99		63		71		98		214	
Sawmills	....		14		11		15		29		46	
Unknown	103		152		204		195		190		178	
Miscellaneous	117		51		66		80		83		111	
Total	528		476		553		797		812		1,628	
Average acreage per fire	296		225		653		125		67		75	
(5) Area burned over (on National Forest land):												
Timbered ... acres	....		29,290		152,517		18,802		6,612		10,418	
Open ... do	....		56,255		106,196		47,706		28,554		79,570	
Total ... do	156,214		85,545		258,713		66,508		35,166		89,988	
Damage to timber, reproduction and forage (on National Forest land):												
Timber destroyed or damaged: Feet b. m.	44,670		23,812		116,504.22		12,760		2,176		4,104	
Timber destroyed or damaged: Value	$88,121		$45,358.53		$207,726.44		$20,997		$2,483		$7,242	
Reproduction value	$179,946		$36,942.75		$113,217.69		$29,365		$2,100		$12,826	
Forage value	....		$1,000.60		$1,642.07		$721		$1,453		$410	
Total value	$268,067		$83,301.88		$322,586.20		$51,083		$5,985		$20,478	

Area burned over (on private lands):							
Timbered	acres		8,667	30,418	9,714	5,221	3,443
Open	do		15,054	78,213	23,776	14,153	30,028
Total	do		21,721	108,631	33,480	19,374	33,471
Damage to timber (on private lands):							
Timber destroyed or damaged	Feet b. m.		6,833	93,420	4,328	1,614	4,216
	Value		$14,401	$189,843	$7,673	$2,216	$9,466
Area burned on both Government and private land	acres	156,214	107,266	361,344	99,988	53,641.83	123,459
(6) Cost of fighting fires:							
Temporary labor		$8,315.81	$10,196.56	$40,972.74	$38,015.64	$14,829.25	$42,362.23
Guard and ranger labor		$4,462.31	$3,941.10	$10,618.43	$6,821.10	$4,666.86	$11,144.49
Tools, supplies, transportation, etc		$2,210.52	$3,400.57	$17,417.13	$18,855.14	$6,722.95	$20,176.38
Total		$14,988.64	$17,538.23	$69,008.35	$63,691.88	$26,219.06	$73,683.10
Total for temporary labor, tools, supplies, and transportation		$10,526.33	$13,597.13	$58,389.87	$56,870.78	$20,353.70	$62,538.61
Division of cost:							
On National Forest land			$12,001.46	$53,176.84	$44,624.04	$18,468.94	$51,406.64
Private land inside National Forest			$2,355.75	$10,842.18	$16,437.69	$5,591.60	$11,505.14
Outside National Forest boundaries			$3,181.02	$4,989.33	$2,630.15	$2,158.52	$10,771.32
Value of cooperation		$5,768.60	$6,491.17	$28,659.70	$4,492.97	$4,841.47	$9,233.00

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